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ABSTRACT

Science is not a phenomenon restricted to one group of people. Instead it is something that is experienced by all, though often its form is unrecognized. Because science is experienced by many, one would expect that different groups of people would share common experiences in science. In an effort to determine whether there are similarities in what various countries feel are the core elements of precollege biology education, a symposium was organized. Educators from around the world were brought together to share their countries' experiences in the design, adoption and assessment of curriculum, and teaching standards. Four basic questions were investigated: (1) What is a concept and what criteria can be used to define a biological concept?; (2) Are there commonalties among countries regarding curriculum standards and/or core concepts that are essential knowledge for all students?; (3) Are there commonalties among various countries of the world regarding the teaching strategies that work best in the classroom?; and (4) What assessment mechanisms have worked well in other countries, and are there any characteristics that can be identified as being essential in selecting appropriate assessment instruments? (ZWH)

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Proceedings from the IUBS/CBE Symposium

Basic Biological Concepts: What Should the World's Children Know?

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Basic Biological Concepts: What Should the World's Children Know?

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About the Cover

This illustration of the global biosphere is part of the NASA Goddard Space Flight Center's program of Earth-science research. It shows for the first time, the patterns of plant life both on land and in the oceans as observed from space. The ocean portion is a composite of more than 60,000 images taken by the Nimbus-7 satellite, launched in October 1978. The land vegetation image is a composite of three years of data, collected during 15,000 orbits of the NOAA-7 satellite, launched in June 1981.

Key:
Dark Green - Tropical. Very productive temperate forests.
Medium Green - Temperate forests and moist savanna.
Light Green - Dry savanna, mixed forests and grassland.
Lime Green - Coniferous forests and grasslands.
Golden Yellow - Semi-arid steppes and tundra.
True Yellow - Barren regions (deserts, ice).
Red/Orange - Highest concentration of phytoplankton.
Purples - Biologically "dead" regions where no phytoplankton exist.
Blues (Aqua and Dark) - Areas of some phytoplankton concentration due to upwelling.

Cover illustration courtesy of NASA Goddard Space Flight Center.

Preface

The Commission for Biological Education (CBE) of the International Union of Biological Sciences (IUBS) met in Colorado Springs from August 30-September 5, 1992. The fact that the United States had an opportunity to host this illustrious group of educators was seen as a unique opportunity to explore the experiences of other countries in establishing and implementing precollege life science education standards.

A symposium was organized in conjunction with the CBE meeting to try to determine whether there are similarities in what various countries feel are the core elements of precollege biology education at various grade levels. Thus the symposium, "Basic Biological Concepts: What Should the World's Children Know?," sought to bring together educators from around the world to share their countries' experiences in the design, adoption and assessment of curriculum and teaching standards. Papers were submitted and individuals were assigned responsibilities to report on commonalities and differences within continents.

The final task was to investigate four basic questions:

•What is a concept and what criteria can be used to define a biological concept?
•Are there commonalities among countries regarding curriculum standards and/or core concepts that are essential knowledge for all students?
•Are there commonalities among various countries of the world regarding the teaching strategies that work best in the classroom?
•What assessment mechanisms have worked well in other countries, and are there any characteristics that can be identified as being essential in selecting appropriate assessment instruments?

Working groups were formulated to try to reach a consensus of understanding on these major questions. An enormous amount of information was processed and shared— the results of which are presented in this volume.

We hope that this material in some small way will contribute to the efforts now underway in the United States to design science standards for curriculum, teaching and assessment. We should be able to learn from the experiences of others who have gone before and benefit from the thinking of our colleagues around the world. This volume attempts to identify areas of study that biologists would agree are key to the understanding of their science and essential for an educated citizenry. Likewise, we are able to identify topics that, while important in some parts of the world, are of far lower priority in other countries. This too will aid American educators and put in perspective the national science standards and assessment project and the reform movements now underway in the United States.

Acknowledgments

This symposium was held in conjunction with the annual meeting of the Commission for Biological Education of the International Union of Biological Sciences. The Commission, established in 1977, consists of up to 25 members from around the world whose task is to initiate and facilitate improvements in the teaching of biological sciences around the world. The Commission is also committed to assisting the international dissemination and interchange of information about biological education.

With the generous support of the National Science Foundation, the Biological Sciences Curriculum Study (BSCS) and the National Association of Biology Teachers (NABT) co-hosted the 1992 meeting of the Commission from August 30th to September 5th in Colorado Springs, Colorado. The symposium was scheduled over two days during this time period and served as a forum for interchange and perspectives among international educators and members of the U.S. teaching profession.

Our thanks to the staff of BSCS, particularly Dee Miller, Selma Stevenson and others for their help with conference organization, logistics and field trips. In addition, our thanks to the staff at NABT, especially Michele Bedsaul, Christine Chantry, Sherry Grimm and Cheryl Merrill for their assistance in the final preparation, printing and distribution of this volume. Without their assistance, this project could never have been completed.

Finally, our thanks to the many teachers and educators from around the world who gave their time and shared with us their expertise to try to reach some consensus on "what the world's children should know."

Joseph D. McInerney
Director, BSCS
Symposium Co-Host

Patricia J. McWethy
Executive Director, NABT
Symposium Co-Host

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Overview

Katherine G. Munson
National Association of Biology Teachers
Reston, Virginia

Without exception, the authors of all papers acknowledge that education reform efforts are underway in their countries. It is evident, however, that some reforms have been incremental in terms of adding new subject matter, while others have been more monumental in their attempts to restructure the entire curriculum and introduce new teaching strategies in the classroom. Making biology more relevant to the lives of students is a key theme. There is general recognition that the preparation of the scientifically literate citizen is best accomplished when course work is made relevant to the lives of students.

What key criteria should be used to determine national standards in biology curriculum? Of those authors who approached this question, most asserted that national standards must be based upon the unique needs of the nation. In developing countries, where there is dire need for students to develop a basic understanding of public health and agriculture in order to survive, biology curriculum stresses soil composition, erosion, crop and livestock production, human disease, and nutrition. Topics in evolution, biotechnology and bioethics are generally given very little attention.

In contrast, in the industrialized "West," the topics of biotechnology and bioethics are gaining significance, and the theory of evolution is a cornerstone of biology instruction. The concept of transfer of genetic material, and hence evolution, is central to the Russian author's proposal of what all Russian students should know.

In general, there seems to be a movement away from teaching biology as a body of discrete facts, although this is still not reflected in any country's assessment instruments. Some have experimented with a very integrated approach to the teaching of life science. An example of this is in Hamburg, where the school system has experimented with the "twelve principles of life active in all organisms" as an integrated "vehicle of basic biological education."

Commonly Accepted Content & Process Goals

Most authors acknowledge that one of the most important goals of biology education in the early years is to instill in children a positive attitude toward science and a respect for nature. Primary knowledge requirements in most countries include the characteristics of plants and animals and how they interact with their environment. Biology at the primary school level appears to be strongly linked to what students observe in the environment around their homes and the school. Curricula in many countries stress topics related to human health as well.

The major tool of scientific investigation at the primary level is observation, and this skill is developed in different ways around the world. For instance, in Europe, students are often required to draw animal and plant life to sharpen their powers of observation. In other countries, the skill of observation is encouraged through exercises in classification, and in a few areas of the world, shared observations in small groups serve as a basis for developing possible explanations and are related to other problem-solving skills.

In lower secondary schools across the globe, the skills of hypothesizing, designing/conducting experiments, and collecting data are added to the earlier skill of observation. There is a trend worldwide to involve students at this level in research, problem-solving, and the

realization that technology plays a crucial role in the study of science as well as in modern life. An emphasis on environmental biology and ecology continues, and a more detailed study of structure and function of animals and plants is included in the lower secondary school curricula. Genetics, heredity and reproduction are emphasized as educators across the globe realize that student interest in human growth and development is paramount during these early teen years.

Generally, upper secondary school is a time for increased streaming of students and differentiation of the curriculum depending upon a student's ability and future plans. However, all countries reporting except Japan require at least one year-long course in biology for graduation. In Japan, as of 1994, there is no biology requirement for graduation from upper secondary school. On the other extreme, in the Near East, biology is taught in most countries for three consecutive years.

Additional skills developed in upper secondary schools include data analysis, technical laboratory skills, scientific methodology and creative thinking. The previously developed skills of observation, data collection, hypothesis formulation, etc. are reinforced. Topics in ecology and environmental science are mentioned by all authors as necessary topics of study. Other common topics include: cell structure and function, reproduction, plant and animal structure and function, reproduction, genetics, life cycles, taxonomy and diversity, and human diseases.

Implementation & Success of National Standards & Goals

The degree of centralization of any reform effort varies tremendously from country to country. Many developing countries are highly centralized and reform is initiated by the national government which sets curriculum and assessment instruments. For example, the Caribbean Examinations Council has developed a regional secondary school exam out of which has emerged a detailed syllabus which is used by every secondary school in the region. On the other hand, individual schools in the Netherlands develop their own curricula and only general goals are provided at the national level.

The United States, Canada and Australia share common characteristics of a decentralized system with local districts exercising a great deal of control over what is taught and how. This makes reform in these countries a slow and difficult process. However, the science and science teaching professions in these countries are at the forefront of reform, so even if the national government has minimal influence, the science and teaching communities are active in encouraging change at the grass roots level.

Many authors cite lack of adequate professional development of teachers as one serious impediment to implementing standards and reform on a national level. For example, in Australia, most teachers are not trained in the new biological technologies; in Brazil, teacher preparation is "poor." The Canadian author points to the fact that teachers feel uncomfortable with nontraditional subject matter (i.e. bioethics, technology and society, etc.) and therefore, avoid including it in their lessons. It is generally recognized that before reform can take place and new standards successfully adopted, the universities will have to change the way they prepare future teachers.

According to many authors, external exams and textbooks still tend to drive curriculum. While individual educators speak to the benefits of portfolios and a variety of assessment

instruments, all countries still rely on a national or standardized exam for measuring ability in science.

Lack of adequate classroom materials and equipment is commonly cited as a problem not only in developing countries but in most countries around the world. Instruction in the process of science which involves students in actually doing science requires significant amounts of lab time, materials and supplies. Facilities to accomplish this kind of hands-on, minds-on science are virtually nonexistent in many parts of the world. This makes it difficult to translate theory and rhetoric into action.

Nevertheless, well-defined visions of change are reflected in the papers and discussions which follow. While there are some striking differences in the way the world's children are now taught and in the content now imparted to them, there is consensus on the need to make science relevant to their lives and the need to involve students in the process of inquiry and the way of knowing called *science.*

IUBS/CBE Symposium Agenda

LeBaron Hotel, 314 West Bijou, Colorado Springs, Colorado, USA

Monday, 31 August 1992
Continental Breakfast

Welcome — Gerhard Schaefer, Chair, Commission for Biological Education, International Union of Biological Sciences — Joseph D. McInerney, Director, Biological Sciences Curriculum Study (BSCS)

Session I: Setting the Stage

Keynote Address — *What the World's Students Should Know About Biology,* Timothy Goldsmith, Yale University; Chair, Committee on Biology Education, National Research Council

The Role of Biological Concepts in Future Education, Gerhard Schaefer, Hamburg University

A Biology Teaching Project, André Giordan, University of Geneva

Session II: Standards for Content & Teaching — Reports from Various Regions of the World

Report #1 — Near East: Saber Selim, Ain-Shams University

Report #2 — Africa: Eunice Okeke, University of Nigeria

Report #3 — Asia and the Far East: Geoff White, Deakin University

Lunch

Report #4 — Europe: Vilmos Csányi, University of Budapest

Report #5 — North America: Iain Taylor, University of British Columbia

Break

Report #6 — South America: Myriam Krasilchik, University of Sao Paulo

Basic Biological Concepts on Human Behavior, Vilmos Csányi, University of Budapest

Adjournment

Reception & Dinner

Tuesday, 1 September 1992
Continental Breakfast

The Role of Assessment in the Development of Standards for Biology Education, Walter MacDonald, Educational Testing Service, Princeton, New Jersey

Teaching Biology in U.S. High Schools: BSCS Perspectives on Reform, Rodger W. Bybee, Associate Director, Biological Sciences Curriculum Study (BSCS), Colorado Springs, Colorado

Charge to Working Groups — Patricia McWethy, Executive Director, National Association of Biology Teachers — (four work groups meet)

Lunch

Report of Working Groups — Discussion

1. What is a concept and what criteria can be used to define a **biological concept**?
2. Are there commonalities among countries regarding **curriculum standards** and/or core concepts that are essential knowledge for all students?
3. Are there commonalities among various countries of the world regarding the **teaching strategies** that work best in the classroom?
4. What **assessment mechanisms** have worked well in other countries, and are there any characteristics that can be identified as being essential in selecting appropriate assessment instruments?

Break

Concluding Remarks — Peter Kelly, The University of Southampton, Highfield, Southampton, United Kingdom

Adjournment

Reception at BSCS

Keynote Address

Timothy Goldsmith
Andrew W. Mellon Professor of Biology
Yale University
New Haven, Connecticut, USA

The honor of addressing such a distinguished international group of educators has led me, I fear, to immoderate folly. There is always hazard in accepting another's suggestion for both topic and title, and in this instance, the danger is real and present. How can I credibly describe what the world's children should know about biology — and in two score minutes and a few thousand words?

I can't. At least I can't in any form that approximates the corpus of knowledge that might be transmitted in a dozen or so years of formal education. But I have observed that most curricular plans are not very successful at this task either, degenerating into lists and outlines of topics, picked clean of meat, bleached like the bones of some animal found perished in the desert. So let me try a different approach.

A major goal of education is to examine the past, the better to prepare the future. Thus guided, let us consider some examples where biological knowledge has contributed to humanity's fortunes and then try to identify major problems that continue to beset humankind. On the positive side of the ledger, we can number improved agricultural crops and methods as well as the control, at least in principle, of most of the infectious diseases and vitamin deficiencies of humankind. These are matters of applied biology, but they are underpinned by a fundamental understanding of genes, cells and organisms — in short, by knowledge that I suspect finds its way into biological curricula everywhere.

When I reflect on the major problems of the world, three seem to be of especially sweeping importance: (1) misery stemming from inadequate health care and nutrition; (2) environmental degradation of a variety of sorts, from the depletion of natural resources, to the collapse of water tables, to pollution of land, sea and stratosphere; and (3) ethnic, cultural, racial and religious strife of many varieties, but frequently manifested as warfare and genocide.

All three of these problems, in some important sense, are political and economic. Inadequate health and nutrition involve ineffective systems of distribution. Surging populations, coupled to understandable human aspirations, stress the environment in countless ways. And war and violence result from unequal access to resources or opportunity.

Each of these categories of problems also has its biological dimension. I have already alluded to agriculture and medicine as applied biology. The perturbations that technology wreaks on the natural world comprise one facet of ecology, a subject so complex in its meshwork of interrelations that hard predictions about cause and effect are difficult to make. But experience should have taught us that the ecological perturbations that are visited on the Earth by human activity are not likely to have unforeseen negative consequences. The building of dams to control flooding has had devastating effects on fisheries around the world. The discharge of gasses used in aerosols and as refrigerants is playing havoc with the ozone shield for reasons only understood after, and as a result of, the fact. One could readily extend this list of assaults on the environment, and each could be used in teaching about biology and our planet — the only home our children will ever know.

It is the final example, however, to which I

wish to address the bulk of my attention. I do this because it leads into a larger issue whose biological dimension is so poorly appreciated. Undeniably, warfare and other forms of violence that humans inflict on each other constitute one of the major political and social problems that we confront. For this reason alone, one might think that the study of such intraspecific strife ought to find its way into curricula in some form other than historical catalogs of events so frequent in their occurrence that they are accepted without further thought, as one accepts the rain. But what is the relation of such matters to biology?

Human strife is certainly not the usual stuff of biological study although it may appear in psychology courses, usually with the peculiar implication that violence between humans is abnormal — surely a projection of moral vision onto the objective study of behavioral reality if there ever was one. In short, it is customary to see social strife as something other than biological, but I wish to argue that this is because of a circumscribed way we have of thinking about the problem and a curious and incomplete understanding of what we ought to mean by the word "biological." The chronic and ubiquitous occurrence of warfare in its various forms is a behavioral propensity of humans that we seem to have great difficulty getting under control, and it is one entree into the larger biological question of what it is we mean by "human nature."

Biology has now reached the stage in its maturation as a science that this question can and should be meaningfully addressed (Goldsmith 1991). Moreover, it is too important to leave exclusively to social scientists, humanists and theologians, although all may have interesting perspectives to offer. What I mean by human nature are features of our behavior (and our psyche) that, in some statistical, aggregate sense help define us as human beings — features that cut across social, economic, religious, ethnic, geographic and historical lines. In various manifestations, these are attributes that have held our attention through recorded history. They are woven into the tapestries of literature, political history, and the codes of law and religion. They are captivating as well as defining, but the heritage they characterized has unfolded in evolutionary time.

The implications of this position for education are plain. Evolution should be presented as something more than a tree of organic forms. It should be displayed as a fundamental natural process which, in the details of its working, has no counterpart in the physical sciences — a creative process with enormous power, yet with no foreordained goal. It is also a process in which *Homo sapiens* has been a very late participant, but it is the process that has made us what we are.

The rewards of this perspective are many, for the study of other animals helps us to understand our humanity. From this vantage point, we begin to see the fundamental meaning of sex: What does gender mean; why does it exist; and what are its implications? How does the concept of parental investment lie behind sexual selection? What insights does this give us about the unrivaled parental investment of human males relative to males of other primates, the pan-cultural propensity of young men for competitive and frequently violent interactions, the attempts by men throughout the world and through history to control the reproductive lives of women, and the uneasy relations between monogamy and various forms of polygyny that characterize human reproductive arrangements?

Through a wider lens, we see that we are each genetically selfish, and that is reflected in our

behavior as well as in emotions such as ambition, pride, greed and lust. But by the same understanding, we are intensely social, with a frequently conflicting array of behavioral propensities. What holds the social fabric together is a manifold of alliances, some spoken, some not, reinforced not only by rules and moral codes of our own devising but, more fundamentally, by the need for respect, friendship and love as well as the capacities for spite, hate and revenge.

Although social structures initially were built upon a foundation of genetic relatedness of the participating individuals (inclusive fitness), they are now cemented by behavioral expectation (reciprocal altruism). Culturally, we make and agree to rules, and we punish those who refuse to play by the rules. Furthermore, we frequently disagree as to what the rules ought to be, particularly if we perceive that they are to our personal disadvantage.

But, despite our urge to cooperate, our evolutionary heritage leaves us vulnerable to a very destructive tendency. Not only were the first human groups likely small, with the members related to each other, but there is abundant evidence that much of human history has been driven by competitive interactions between groups. As a result, we tend to define ourselves in terms of the groups to which we belong, and although the groups are now so large only a relatively trivial fraction of the genetic diversity of the species can be associated with even the vast and artificial phenotypic subdivisions we refer to as race, we frequently behave as though we are operating in a world of tiny tribes of relatives. Our misfortune and our challenge is that it is such a short step toward racism and "ethnic cleansing" and "final solutions." It is hard to identify a single human group conflict involving violence now in existence, and there are many currently raging, that does not also involve appeals to ethnic identity. The fact that religion has so frequently been used as the unifying token of the groups, or that for the last century Marxism has used economic class to the same end, does nothing to dilute this proposition.

Let me now address the rumblings of those who would have us believe that viewing human behavior in this light somehow ensnares us in a coil of our own DNA. These are echoes from the past, but they still reverberate loudly. Politically, they are a persistent reaction to a social Darwinism that has no place in what I am saying. Intellectually, they are the heritage of an understanding of causation that posits nature versus nurture, heredity as an alternative to environmental influences in the ontogeny of behavior. So let us be clear: Genes are worthless without an environment in which to act, whether that be the environment of the cell for the manufacture of an enzyme or the social environment of a young primate for the formation of functional behavior with peers and mates. Most developmental psychologists and a growing number of psychiatrists have now got this right, but it seems to be a difficult concept to convey to the lay public, a task at which our educational system has largely failed, partly because of our cultural history and partly because we teach genetics through the mirror of simple, classical Mendelian examples.

Hidden in the preceding paragraph is another important concept. Brains are responsible for both thoughts and behavior, and as brains are physical entities, thoughts and behavior have a representation in the synaptic architecture of brains and the activities of their constituent neurons. Brains, like all other features of the phenotype, can be altered by evolution. Brains can also be changed by the experience of the individual, a process that embraces learning. In each case behavior may change, and in each

case there is a physical basis for the change. Sorting out the two causative processes is not a trivial challenge, as they are intermingled.

Evolution can produce a brain that directs complex behavior along alternative paths when confronted with different environmental stimuli. For example, acorn woodpeckers can be either communal or single-pair breeders, sedentary or migratory, depending on the food supply; which path is chosen does not require learning by individual birds. To take a parallel example from human behavior which may suggest some corresponding phenotypic complexity, whether the local mating system is monogamous, polygynous or polyandrous depends, it is said, on culture, but that explains surprisingly little. Cultures are themselves responses to environmental conditions — and organisms are part of the environment of other organisms. Polygyny tends to be most pronounced in strongly stratified societies; polyandry, which is very rare, is found where land is scarce and the opportunities for migration and alternative avenues to resources are very restricted.

Although we may be beginning to address the false dichotomy of instinct and learning in our educational process, there is another manifestation in the equally misleading apposition of culture and biology. As a highly intelligent social species, we have invented culture; it is the ultimate expression of our sociality, but it is underpinned by the psychic equipment with which we have evolved.

In a very important sense, culture is as much a part of biology as is the species-species social system of any primate. Our language confuses and obscures this point, and the confusion arises from a couple of sources. One is related to the nature-nurture dichotomy discussed above and, at least in the Western world, stems from a religious and philosophical tradition that sets humankind apart from the rest of the natural order. A second source of confusion derives from the very different processes that are involved in evolutionary and cultural change.

As culture is a human invention that in its propagation can leap across both space and time, it is seen not only as having unique properties, but these properties are assumed to set it apart from biology. Human culture remains the work of a single species, and it has been shaped by the desires and strivings, the cleverness and the curiosity, the artistry and the aesthetics of individuals who are part of that species — impulses and abilities that are themselves the result of evolution. Like other aspects of our behavior, the invention of culture is part of our phenotype. Culture is part of our biology.

Let us return to the example with which I introduced this theme — organized aggression between groups of humans. It is frequently suggested that this feature of our behavior is cultural, not biological. Suppose I am insulted or harmed by another individual. If I strike out in rage, those who recognize the role of the hypothalamus with limbic system in mammalian behavior would see little difference, even homology, with the behavior of a snarling dog contending for a bone.

Suppose my adversary is larger, and my cortex intervenes. I may seek the help of a friend or relative, or I may wait for a more propitious opportunity to attack, behavioral alternatives that are both known in chimpanzees. The seeming intrusion of the cortex does not make my aggressive response uniquely human.

Suppose I choose a nonviolent form of response, say a verbal attack on my antagonist's

character which has the effect of reducing his status and, thus, his capacity to compete with me? That sort of verbal aggression may be uniquely human, but simply because it exploits uniquely human linguistic capacities and structures, hardly makes it less biological. I do not have the venom of a rattlesnake, but like the rattlesnake, I am able to use the equipment with which I am endowed. Similarly, if I perceive that my family, tribe or larger social organization is threatened, I may mobilize support on a scale that is also unprecedented in other animals.

If I employ technology, that is simply using my wits. Using my wits is part of my behavioral phenotype. If I try to enlist the support of others by playing on their emotions by lies and other propaganda, that is using my wits to engage their limbic systems and involve them in activities that rational analysis might lead them to doubt are in their best interests. To suppose that any of this is not biology is to cling to the cultural myth that our roots are not biological.

Next, a word about causes. I wish our educational system were more effective in conveying the multiplicity of meaning of the word "cause." In biology, in particular, there is abundant misunderstanding and confusion. In parallel with the Aristotelian sense of efficient cause, the concept of proximate cause embraces the gamut of biochemical and physiological events that occur when a cell or an organism simply functions. Thus, the cause of a behavior might be traced to the pattern of activation of nerve cells. By extension, however, one should also include the events that have occurred during the lifetime of the individual, changing its structure and its functional properties. I would include here those events and process that we refer to as learning. The causes of Midori's music in Carnegie Hall, therefore, include not only the activity of her neurons between 8 and 9 p.m. but the hours she has spent practicing since she was eight years old, as well as the behavior of individuals of influence who heard her play on previous occasions.

In contrast to these matters of proximate cause, there is the Aristotelian notion of final cause or purpose, a concept that had no scientific basis until we began to understand the process of evolution. Ultimate cause speaks to the sifting of genotypes in evolutionary time, a process driven largely by natural selection. As a vehicle for understanding, it is complementary to explanation of proximate cause, not an alternative. As Ernst Mayr has pointed out, a study of genes and their role in metabolism or in the control of development will offer no insight as to why natural selection has formed one species exhibiting sexual dimorphism and another that does not, or how sexual dimorphism (or its absence) contributes to the natural history of a species.

Finally, a central purpose of biological education should be to convey science as a powerful way of understanding the world. There is increasing awareness that science as approach and method is best conveyed if children can be engaged, hand and heart as well as mind, in the process of discovery for themselves. If they can be led to see how their personal "theories" of cause and effect can be challenged by observation and simple experiment, they will carry a profoundly important lesson into their adult lives.

What the world's children know about biology is what tomorrow's citizens and leaders will know. I have been painting with a broad brush, and my canvas has few details, but it is a picture of science education that relates to the reality of a world increasingly savaged in

the name of human fulfillment, a world in which our technological cleverness is outpacing our own understanding of ourselves. Biology — specifically at the interface between neuroscience and the study of evolution — offers us perspectives that, if properly understood, can help to heal our self-inflicted wounds. The pace of scientific discovery during this century has been astounding, and it will likely continue to accelerate. Nevertheless, as a species we seem to know so much while comprehending so little.

References

Goldsmith, T.H. (1991). *The biological roots of human nature.* New York: Oxford University Press.

Setting the Stage (The following represents summary notes of presentations.)

The Role of Biological Concepts in Future Education

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The concept-centered approach to teaching has never caught on. Instead, most science teachers use an issue-oriented approach to instruction in the classroom. Two concepts — energy and life— will be presented here to demonstrate how they can be used effectively in teaching biology.

First, a concept can be defined in a new, threefold way. Looking at "equilibrium," biologists teach this concept without always knowing all its parts. A concept is a functional unit of the mind which is invariant over a certain time and depicts a class of similar events. It is characterized by a name that more or less directs human activities.

How can we measure concepts? We can do so by visualizing a concept in layers, beginning with a deep understanding (core) to an outer layer labeled "surface understanding."

We can have different levels of understanding, and concepts themselves can overlap and link together in associations. For example, concepts of life, health and environment are all interlinked in logic as well as in reality.

Teachers introduce a concept, such as energy, without always explaining the various dimensions of the concept. For instance, teachers often discuss the quantity of energy but may fail to realize that the quality of energy also differs from source to source and may not be related to the quantity of energy emanating from a particular source. A little energy can be used to gain more energy — for instance, when energy is used to carry information. Individuals receiving energy-driven information often reuse this information to produce more energy.

If you ask students what their major association is with energy — whether it be force, current, water, heat or work — most students will focus on forms of energy impacting their daily lives and will respond by identifying force. Force has direction; energy does not. This indicates that students really don't understand the concept of energy. Light and strength are not often identified by students as forms of energy. Student concepts of energy are almost always physical and impact on living phenomena. Students see very little association between energy and biology/living things.

Next, students were asked to define the concept of "life." Only 12.8% of the answers related to the biological aspects of the concept. Another 8.6% were aesthetic (art), and 10.6% related to the religious aspects of the concept. Biology students did associate the concept of life with sadness, love, joy and other pathological behaviors; concepts are taught from a disciplinary standpoint, and teachers may wish to adjust their teaching strategies to present these concepts from an interdisciplinary point of view to better parallel how students already understand the world.

My research identified the following basic concepts of biology: bioenergy, biomass, biodiversity, biocomplexity, biological order, biological homeostasis, biological polarity,

biological causality and biological regulation. All these concepts, while appropriate to the core of biology, have more general components, as well. All concepts have a polarity, and there is an equilibrium we can see along these continuums.

Setting the Stage (The following represents summary notes of presentations.)

A Biology Teaching Project

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Two questions that all educators must address are: What knowledge should be handed down to the next generation and how should it be transmitted?

The amount of knowledge transferred to students as a percent of time spent teaching is very small. Students may remember the word "DNA" and maybe even a picture of its structure, but they don't often remember how it works.

As an example of how little knowledge students retain, Figure 1 represents various students' conceptions of digestion. Some believe that there are two separate tubes (one for food leading to the stomach and another for fluids leading to the bladder). This figure, as well as Figures 2 and 3, demonstrates the great misconceptions that students come away with, even after a basic biology course. Also, students have drawn pictures that show that roots take nutrients into the tree's system from leaves that have fallen to the ground — they remember nothing about photosynthesis. Learning depends on students' preconceptions, and teachers must consider these facts when designing a curriculum and selecting teaching strategies. If students' preconceptions are not considered, teaching will never be successful.

Teachers must not ignore students' preconceptions and, in fact, must strive to identify exactly what these are. They should use preconceptions as elements of their course, as a source of motivation, and as material for didactic processing. Given a basic theme, a good teacher can transform these misconceptions by first elaborating on them and then refuting or eradicating them.

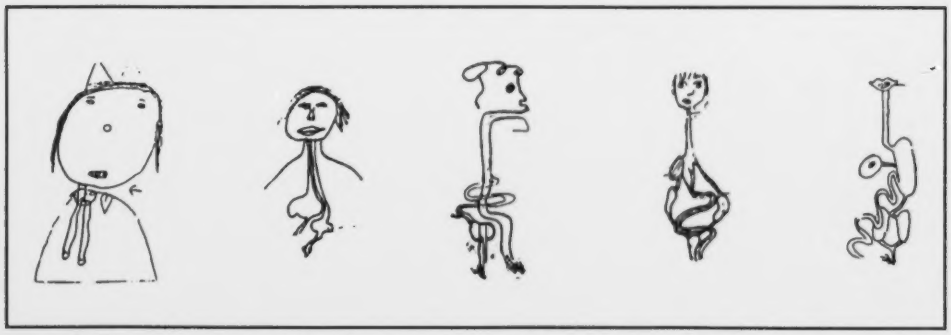

Figure 1. The same misconception after one, two, three or four courses on digestion. Some pupils think that there are two tubes; one for food, another for drink.

This process produces a lot of anguish. A student will not change his/her preconception simply because it doesn't work; rather before it can be replaced by another, the modified concept must be proven to better explain the answer to real problems. A teacher's role is to cause interference with an existing concept and introduce a relevant conceptual imbal-

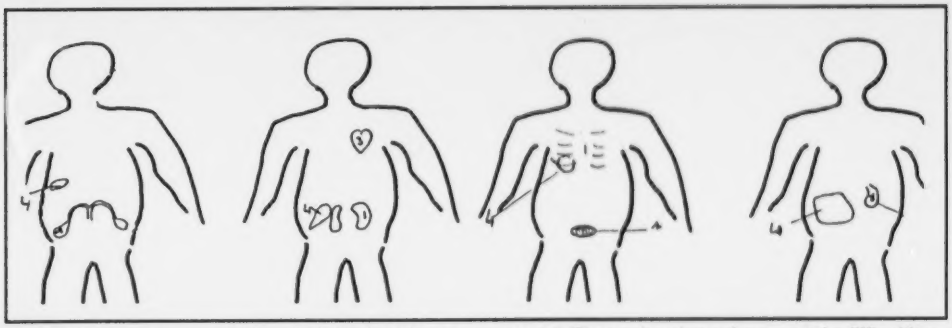

Figure 2. Some incorrect ideas held by healthcare personnel. These drawings show certain difficulties noted amongst student nurses during their training period.

ance (raise questions, investigation, etc.). It is important to enhance confrontations and then introduce some formalism by making models, schemata, etc. The teacher must organize data to do this and must employ a variety of strategies.

Knowledge of biology should enable students to solve existing problems. Education must provide students with:

•Prerequisites for a scientific attitude (self-confidence, creativeness, open-mindedness, awareness of natural environment, inquisitiveness, investigative activity, etc.).

•Mastery of investigative approaches (argumentation, model-building, control of information, analytic/systemic reasoning, etc.).

•Organization of knowledge around structural concepts (matter, energy, space, time, information, organization/system, evolution, function, equilibrium/interaction, memory, identity/recognition).

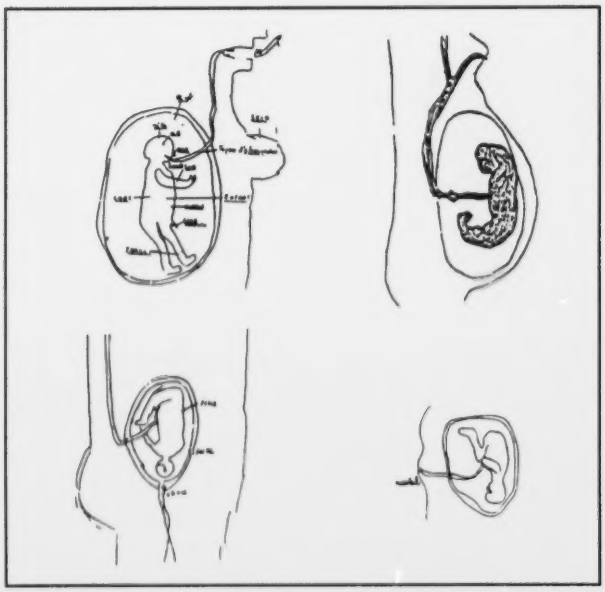

Figure 3. The life of the fetus as seen by pupils (ages 10-12). Top left: This drawing shows the baby getting food directly from the mother's mouth or breast by way of a "medical tube." Top right: The baby breathes the air from the mother's lungs. Bottom: The baby obtains air from outside the mother's body.

Question: Aren't there misconceptions that teachers have? Has any work been done on this? Yes, teachers do have misconceptions, and we need to find out what these are.

Setting the Stage (The following represents summary notes of presentations.)

The Role of Assessment in the Development of Standards for Biology Education

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Since the 1960s, people across the United States have been concerned that students in this country are not learning enough for the world that awaits them. This concern was further fueled by the publication of *A Nation at Risk* in 1983. The states responded to this concern by developing a "back to basics" movement and, for accountability purposes, introducing basic competency testing. By the late '80s, 47 states mandated such testing.

Administered by the Educational Tesing Service (ETS), the National Assessment of Educational Progress (NAEP) is perhaps the largest and best known of U.S. efforts to measure competency. NAEP attempts to provide a high-quality index of what students know and can do and to determine trends across time in their educational achievement. The major objective of NAEP is to measure growth or decline in performance, and its efforts are clearly tied to the issue of accountability and a determination of what benefits have been derived from the billions of dollars spent each year on American education. Implementation of NAEP, then, requires a statement of what goals the educational system is attempting to achieve and the development of exercises to measure the achievement of those goals.

Over the past several years, NAEP and many other reports and studies illustrate problems in U.S. education, and many polls show that citizens overwhelmingly support change and the development of national standards and national tests. Publicly-perceived benefits of such standards and tests would be instructional improvement and accountability. Citizens, educators and parents desire instructional improvement, and taxpayers want measures to determine student achievement, graduation and college admission; teacher promotion or penalty; and school performance.

However, the hazards of standards and tests are:

- Standards/tests do not take into account the differences among states or nations.
- In the past, standards had a tendency to be weak and reflect the lowest common denominator (i.e. the shallowest education). On the other hand, cautions must be exercised to insure that the new standards do not set unrealistically high expectations for students.
- Equity issues of "fairness" are difficult to deal with, as all students do not have the same opportunities to learn.
- Tests may not force reform. It has not worked in the past because it demoralizes teachers and distorts learning.
- Who sets them? Are they mandatory? The questions are always raised as to who will set the standards and whether they should be voluntary or mandatory.
- Who integrates standards across disciplines? To have "graduate student" level expectations in the sciences, humanities, social studies, and mathematics is not acceptable, and it is doomed to failure.

With all this in mind and the polls behind them, in late 1989, the nation's first education summit brought together the President and the nation's governors to issue the National

Education Goals. This group also created the National Education Goals Panel (NEGP) to monitor progress toward this goal. NEGP issued an annual "Goals Report Card" by compiling data from NAEP and the Educational Testing Services Advanced Placement Program.

NEGP was created by executives; it did not represent the legislators — Congress. So, an organization was created as a spinoff of NEGP to include Congress and develop recommendations on the feasibility of national standards and testing in education. This group is now called the National Education Standards and Assessment Council.

In January 1992, the National Education Standards and Assessment Council issued the following recommendations:
•National standards and assessments are feasible and desirable.
•Standards must reflect high expectations, provide focus, but not be prescriptive. They must be national, not federal; be voluntary; and be dynamic.
•Assessment instruments must be state-of-the-art, assess individual students, assess large-scale samples, be voluntary, and be dynamic.

There are currently no truly national science standards. There have been state frameworks, professional society efforts (i.e. AAAS 2061 and NSTA-SS&C), and there have been national standards that in minimal form describe the NAEP assessments. The current National Academy of Sciences effort is the first attempt to formulate national standards to address curricula, teaching and assessment.

Why do we need standards? They facilitate communication and provide the common language to help teachers know what to teach, to help publishers and curriculum developers, and to help test developers know what to assess. They also provide criteria upon which curriculum, best practice and student work can be judged.

The implementation of new standards requires assessment to play a dual role — one for accountability and one for instruction and learning. No one assessment mechanism can do both, or both will suffer.

For accountability purposes, broad knowledge and skill outcomes are measured at key points. The assessment instrument must be as efficient, reliable and as valid as possible. For instance, tests must:
•Assess students' as well as the schools' efforts to teach them.
•Be efficient, combining accountability with performance.
•Be valid, be developed by teachers and others in the discipline, and be rooted locally.
•Be reliable.
•Focus on improvement and not blame.

Assessments to improve instruction and learning should:
•Be valid — developed by teachers and others in the discipline.
•Be fully integrated into the classroom so that assessment and instruction are no longer distinct functions, but reinforce each other.
•Be diverse — use "multiple sources and multiple indicators."
•Be performance based — testing performance, using portfolios, projects (including lab work, experiments, writing, etc.). Be increasingly involved with the use of technology.
•Provide continuous feedback to teacher and student, so together they can plan next steps.
•Emphasize what students can do (i.e. enable them to demonstrate their understanding).
•Emphasize higher-order skills (i.e. inductive, deductive and spatial reasoning; verbal anal-

ogy; and creative thinking).
•Actively involve the learner (i.e. have some real life applications).
•Involve the teacher as mentor rather than as a dispenser of knowledge.

The College Board's Advanced Placement (AP) Program serves as a good example of the use of standards and assessments in U.S. high school education. The primary purpose of the AP Program is to establish the frameworks and supporting networks for the development and implementation of college-level courses in high schools and the development of examinations to certify students' acquisition of college-level skills and knowledge. Curricula for these courses are designed by college faculty and AP teachers to emulate the best college-level instruction, and exams are constructed to assess student mastery of the concepts covered through multiple choice and free-response questions.

If the AP examinations have validity with respect to subsequent college achievement, then it might be expected that students who have participated in the AP Program in secondary school would equal or exceed the achievement of their non-AP college classmates. Over the past 25 years, dozens of studies have appeared in the research literature assessing the validity of various AP examinations by comparing the college achievement of AP candidates and their non-AP college classmates. These studies (many in matched samples) describe what is known as the "AP effect" and have found that AP students are:

•Better prepared academically on all preadmission measures of ability and achievement.
•More likely to specialize in majors that had tougher grading standards.
•More likely to complete more course work, consisting of higher level courses, and less likely to drop out.
•More likely to take more college courses in their AP subjects (2-5 times).
•Perform significantly better over four years in their course work (i.e. higher GPA).
•More likely to be superior in terms of leadership and significant accomplishments.
•More likely to graduate with a double major.
•Twice as likely to go into advanced study — Ph.D. programs, medicine, law.

It is also interesting to note that the greater the AP grades of the student, the greater the AP effect. The AP effect is comparable for major groups of students; i.e. it works regardless of gender and race/ethnicity.

In conclusion, the Advanced Placement Program demonstrates that national standards within a discipline can be developed and applied in a manner that brings a challenging, quality education to students. However, even when we have reached the significant milestone of realistic, integrated standards and teachers who have the ability and resources to implement them, our success in reaching all students will be attenuated unless we also address the even more challenging social issues of poverty, parental involvement, and the home environment.

Continent Reports

Africa

(A continental report on Africa was not given, as the individual responsible was not able to arrive in time for the Day 1 presentations. Country reports from Kenya and Nigeria are reprinted in the Contributed Papers section, pages 34-41.)

Asia & the Far East

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(Papers were received from Japan, China and Australia.)

Curriculum reform and change are occurring everywhere in the region. There are differences among countries, but most programs focus on very traditional topics, such as life cycles, details of plant and animal function, and taxonomy. New elements are beginning to emerge — for instance, environmentalism, protection of endangered species, population control, etc.

Textbooks are very influential in both China and Japan, with content strictly controlled by law, even to the extent of dictating font size and character style. Revision of textbooks takes place every 10 years.

Reform, consisting of more emphasis on student research projects, is becoming popular across the region, and emphasis on the science of daily life and the effects of technology are increasing. There is general concern that students must be taught to understand the methods and processes of science, and the most common skill taught in elementary school is observation, with an increasing realization that instruction must be activity based. However, as of 1994, biology (in Japan) will become an elective instead of a compulsory subject.

Furthermore, the gap between policy and practice which is common in Australia is prevalent elsewhere as well. The goal of scientific literacy is common across many levels of education and across many countries. Human impact on the environment is another common goal of education. Educators agree that students must study the ways man interacts with the whole living world and have an increased awareness of our role on Earth.

Many countries are trying to come up with some localized curricula to make science more relevant to the students. In Australia, for example, there is a massive exodus of students from traditional biology to human biology courses focused on contemporary biological issues which are perceived as more relevant by students. Many biology practicals are still cookbook labs, and professional educators are trying to encourage teachers to introduce more investigative, open-ended activities, which would encourage creativity in their students.

Assessment can be both external and internal to the school. It is fair to say that a whole range of mechanisms of assessment are being used. Professional development is a must in all the countries, and all are dealing with the problems of how to retool teachers so that they can deal with bioethical issues, biotechnology, and other new knowledge and methods of instruction.

Europe

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University of Budapest
Budapest, Hungary

The major driving forces behind existing European biological curricula appear to be:

(1) Structure of biological science — including the ongoing debate between educating the general audience vs. future scientists.

(2) Motivation of the pupils — interest in themselves, behavior, etc.

(3) Practical needs of the society.

Taxonomy, cell biology, biochemistry and molecular biology, physiology of plants and animals, genetics, ecology, ethology, evolution, and human biology are all common elements in traditional European curricula. Also, they reflect students' interest in the human body, behavior, pets and nature.

Health and hygiene, sex education, agriculture, environmental problems, biotechnology and diseases (AIDS) are common core subjects that relate to biology's interface with the needs of society.

Summary of Four Countries: Hungary/Germany/Netherlands/Great Britain
In the elementary school years, the skill most often emphasized is observation — observation of living things. The science taught is generally integrated and focused on the students' environment. Students learn the characteristics of plants and animals and about the dependence of man and nature.

In upper grades, the focus is on the diversity of life, ecology, behavior and the human body. Many of the same concepts are taught at the elementary level but at a higher degree of sophistication. The German school system adds some more material on the relationship of man to technology and the philosophy of science.

In Great Britain, the focus is on teaching the skills of asking questions, predicting, hypothesizing, observation, measurement, interpretation of data, and evaluating evidence. Students develop a knowledge and understanding of energy flows and cycles of matter within ecosystems and similar processes.

All countries seem to stress abstraction of dominant biological concepts, such as life processes and the organization of living things, inheritance and evaluation, human influences on the ecosystem, and energy flows. Required skills include:

- Observation.
- Data collection.
- Interpretation.
- Formulation of hypotheses.
- Reading and making photos, drawings, etc.
- Using taxonomic keys, etc.

There is general agreement that more emphasis needs to be placed on the concept of complex systems (e.g. defining what is a system, system behavior, system cybernetics, etc.). Sample systems should be studied from the level of the cell to the body, community and the biosphere. Also, more emphasis needs to be placed on the use of models in natural sciences by first defining a model and then having students design one. In addition, more emphasis needs to be placed on human ethology (i.e. the evolutionary roots of human behavior).

Near East
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Ain Shams University
Cairo, Egypt

All countries in the Near East have national curricula. Biology is not taught as a separate discipline until secondary school, and it is taught every year for the last three years of

schooling.

The region is influenced greatly by the BSCS curriculum from the United States. The environmental approach is used more frequently than the molecular approach to the discipline, and social approaches are now being adopted by many countries in the region. Biology at the primary and intermediate level is taught as part of an integrated science curriculum, and its central focus is on health and the environment.

Building on the science of primary and intermediate schools, the theme for Year 1 Biology (Grade 10) is "Biology and the Biosphere." Study is made of the adaptation of land and animals to the environment, classification, the cell and its components, parasites, plant tissues, heredity, symbiosis, energy pyramid, food chain, pollution, plant production, marine resources and desertification.

The theme for Year II Biology (Grade 11) is "Unity and Diversity Among Organisms." This course deals with nutrition, respiration, movement, sensation, osmosis, photosynthesis, digestive systems, enzymes, capillary action, circulations, support systems, glands and hormones, etc.

The theme for Year III Biology (Grade 12) is "The Replication of Life." This course covers heredity, reproduction, continuity of life, evolution, the improvement of future life, population problems, biotechnology, the origin of life, etc. Saudia Arabia and some others, however, do not teach evolution because this topic contradicts their religion.

A survey was conducted, and according to parents in Egypt, the following important bioethical issues should be added to the curriculum:

- Starting of ova and sperm banks.
- Artificial insemination from donors.
- Surrogate mothers.
- Human organ banks.
- Mercy killing.
- Genetic engineering for biological warfare.
- Genetic screening.
- Extension of life span.

Examinations in the Near East assess rote memory but not skills or attitudes. There are 35 weeks of schooling during the year; biology is taught for two hours per week in Grade 10 and for three hours per week in the final two years of study.

North America

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University of British Columbia
Vancouver, British Columbia, Canada

We must remember that most students will never study biology beyond the 10th grade when we address what concepts are important. Our goals are quite simple: We'd like all students to develop positive attitudes toward science; to know the process and skills of science, as well as some content; and to be creative, rational and critical thinking individuals.

Later on in their education, we expect students to understand principles of science, assess their impact, conduct inquiry, and be knowledgeable about the history of science and value its habits of mind. Science must teach concern for life, be relevant to individuals, and teach students to take responsibility for the environment. Students must develop an appreciation for the dynamic nature of scientific ideas and the breadth of science applications in the home, workplace, recreation, transport systems, etc.

In North America, there is some consensus that the unifying concepts within biology are to be found in understanding cellular activity, genetic control, reproduction, energetics, ecology, and regulation and control (maintenance and stability). These concepts have implications for teaching, and before reform takes place, the following conditions must exist:

(1) The teaching profession must promote curriculum change and deal with controversial issues. This type of change is not easy. For instance, attempts to diversify the curricula and downplay human biology (at upper levels) have often been unsuccessful because teachers feel more comfortable teaching this traditional subject. A manual for teaching controversial issues is needed.

(2) We need assessment instruments that are consistent with stated goals and objectives, based on a student's level of learning, examinations and practical work.

(3) Teaching the scientific process must become the core of any science course. What is needed is better teacher training and preparation.

(4) Teachers must recognize and learn to use all resources. If they don't, students will never know how to make use of available resources.

(5) Students experience physical, chemical and emotional changes during middle school, and teachers should be able to use these changes to further their goal of science teaching.

(6) The textbook industry must better reflect the needs of students.

(7) External exam systems must be overhauled so that they truly measure outcomes and cease to drive curriculum.

This is not to say that there are no curriculum changes taking place. Across all of North America, there seems to be some progress and a remarkable commonality among the reforms.

South America

Myriam Krasilchik
University of Sao Paulo
Sao Paulo, Brazil

There are commonalities in the biology curricula among the 13 countries that comprise South America. Over the years, the curriculum has been influenced by certain historical events — for instance, the "Cold War" of the '50s, the energy crisis of the '60s, the environmental problems of the '70s, and the technological war of the '80s, etc. These events influenced what was taught, how and by whom. There has been a shift in recent years from an emphasis on preparing scientists to preparing responsible citizens.

Major curriculum writing efforts in the region began in the '60s. First, educators considered science as a product; then, science as a process; and now it's very important to consider science as an institution.

Every two years, educators in South America have a conference in Brazil on the status of biology education. There continue to be three important sources of pressure on the curriculum — pressure from the State Ministry of Education, the college entrance examination, and the textbook publishers.

I conducted a study on the frequency of themes in high school programs in Brazil. Within five key topics, there were some surprising findings:

(1) Cell structure ... Cell morphology, origin

of life, animal histology and living beings are taught most frequently, whereas cell theory and plant histology are given less emphasis.

(2) Organism diversity ... Generally, the form and function of animals and plants are well covered, but taxonomy, fungi and metazoa are not frequently covered.

(3) Heredity ... Human and population genetics receive very little coverage, but reproduction, embryology and Mendelian genetics are very popular.

(4) Evolution ... The theories and mechanics of evolution are the focus, with less time devoted to human evolution.

(5) Ecology ... Man and the environment and the associations among organisms are well covered, but biogeography frequently is not covered.

One problem in Brazil and elsewhere is that teachers have low esteem, and they use the textbook as a support mechanism. Preparation time is short as well. However, the problem is not resources; science educators and administrators are a very powerful lobby, and there is much financial support for classroom teachers.

Students spend 10% of their time studying biology while in high school and take biology for three years at the secondary level.

Working Group Reports

Working Group #1 ... *What is a concept and what criteria can be used to define a biological concept?*

A concept is a construct of the mind depicting reality and consists of three parts — a name, the logical core and an associated framework (personal framework). What does this mean functionally?

When we speak of a concept, we are describing reality in a way that enables us to store information about an aspect of reality in our memory. A concept must have meaning and must facilitate learning and improve decision-making. Concepts are stable over a certain period of time and influence decisions at both a conscious and unconscious level.

Educators are tending today to focus on issues instead of teaching biology as a separate discipline. Many concepts transcend biology, and special skills are needed by instructors to effectively teach concepts. For instance, a teacher must respect the views and conceptions of students and let the students express themselves.

It is essential to involve students in the process of teaching concepts. The use of association tests in a classroom can be a valuable tool for structuring a discussion of biological concepts.

Recommendations ... CBE should develop a position paper, published in different languages, on the nature of biological concepts; develop a training manual for teachers to assist them in teaching these core concepts; and suggest case studies that teachers could use to illustrate concepts in the classroom.

Working Group #2 ... *Are there commonalities among countries regarding curriculum standards and/or core concepts that are essential knowledge for all students?* [Rapporteur: Gordon Uno]

This working group limited their discussion to a target population of students age 14-17. The first task was to establish criteria for selecting the key concepts to teach students. What followed was a discussion as to the appropriate goals of biology education.

The goal of biology education should be to prepare students to be good citizens of the world. This means teaching our students the cause and effect of their actions, the interdependence of world events and living systems, decision-making skills, and their roles as family members, producers and consumers. Students should have an understanding of population growth and its effect on the environment and should develop an awareness of responsibility to the environment. Education should:

- Develop an individual's intellect and prepare him/her for a profession.
- Develop an individual's personality in terms of ethical reasoning.
- Teach students that their actions have consequences.
- Help students in decision-making and applications.
- Transmit an understanding of what biology is and what it can do for them.
- Develop essential skills, including the following — observation, communication, experimentation, hypothesis formulation, experiment design, classification, data analysis, apparatus and tool handling, drawing/illustration, question raising, etc.

Certain concepts were common to all country reports. These were: cycles/development; evolution; nutrition/health; genetics, continuity

and reproduction; biology as a process; structure and function; adaptation; biodiversity; hierarchy of life; homeostasis and regulation; ecology/equilibrium; behavior; bioenergetics; bioethics; and biotechnology

Observation ... Care must be taken to begin instruction with examples from the real world and develop the concepts from that rather than the other way around. If teachers proceed from concepts to reality, students will be turned off to biology before they get to the practical applications of the science.

Question ... How were the concepts listed above selected from among the many now taught? Many of these are overlapping, and there seems to be a mixture of concepts and tools; e.g. biotechnology is a tool and not a concept.

Response ... Concepts listed here are what we found to be common around the world — they haven't changed; they are enduring — and what we add are new ways of teaching concepts.

Working Group #3 ... *Are there commonalities among various countries of the world regarding the teaching strategies that work best in the classroom?* [Rapporteur: Rodger Bybee]

What are the characteristics of exemplary biology teachers? The group agreed that exemplary teachers establish a learning community in the classroom by using groups and cooperative learning strategies and actually engage students in biology by making connections to the students' world and making instructional decisions in terms of student learning. They use a variety of resources and strategies in the classroom and incorporate both pedagogical and content knowledge in lessons by using analogies, examples, etc. And, possibly most importantly, good teachers establish positive interpersonal relations with students (e.g. they listen, care).

What are the characteristics of successful curriculum material?

•It relates to students, is relevant to their experience/environment, and is student-friendly.

•It "simplifies" or exemplifies complex concepts.

•It is designed with a purpose (e.g. to engage, explore, etc.).

•It provides linkages and associations among concepts.

•It models effective teaching (e.g. cooperative learning).

How do you achieve success in the classroom? Teachers need time, resources, training and materials that are inexpensive, immediately available and familiar to the students.

Question ... Are the qualities of a good teacher for biology different from a good teacher in other subjects?

Response ... There was a difference of opinion on this question. Some felt that there were no inherent differences among good teachers in any discipline; whereas, others felt that there were certain characteristics unique to good science and/or biology teachers.

Recommendation ... CBE should develop a pamphlet illustrating how to achieve the goal of developing responsible, biologically literate world citizens.

Working Group #4 ... *What assessment mecha-*

nisms have worked well in other countries, and are there any characteristics that can be identified as being essential in selecting appropriate assessment instruments? [Rapporteur: LeRoy Lee]

Assessment was defined as a process of gathering information to meet various needs and must involve multiple indicators as multiple sources of information. Presently, the education community needs to assess student knowledge of content and concepts, the purpose being to measure learning and to determine promotion and the proper grade level for students. To date, the primary source of information for making these determinations has been multiple choice tests.

The next question is what should IUBS/CBE do to improve the assessment process? Perhaps they should measure student learning for the purpose of feeding what we learn back into the process so as to initiate changes that would improve students' knowledge, investigative skills and decision-making. Assessment can be used constructively to change curriculum and teaching strategies so as to improve student learning.

The type of assessment instrument chosen will depend on how the information collected will be used. Various instruments — multiple choice tests, paper/pencil essays, and performance assessments that involve situation surveys and/or interviews — can and should be used. However, it is important that the data collected through these various assessments be used to improve the curriculum and processes of instruction and learning.

Recommendation ... IUBS/CBE should define the needs that can be met by using assessments and the various instruments that are available. The Commission should encourage colleagues to look beyond multiple choice tests and beyond the immediate need to measure student learning for grade level determination and consider using assessment to change and improve the teaching and learning processes.

Concluding Remarks

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Many questions have been raised during the course of these proceedings: What is going on at the moment that is dictating our thoughts and discussions? Why haven't we discussed parent education, adult education, etc., if what we want to see is an educated citizenry? We have discussed what we would like to see stressed in upper secondary school, but the list of concepts presented is probably not appropriate for seven-year-olds.

For instance, the human genome project will enable us to crack most genetic codes within the next 10-20 years, and certainly this will have a tremendous impact on our students. Shouldn't we think ahead and predict what the world will be like for our students? This should guide our teaching. We, as biology teachers, must deal with the interrelationship of biological sciences, social sciences and moral/ethical issues. This means reformation of our whole teaching structure.

We must distinguish between assessment for improvement and learning and assessment for accountability. We should concentrate on the former, not the latter, as the previous working group has recommended: I suggest this be an emphasis of the Commission in the future. The reality is that assessment drives teaching which, in turn, determines curriculum. The ideal is the other way around.

If, in fact, curriculum is to come from the context of the student, then maybe there is no such thing as a universal set of goals and objectives. **We must learn to accept a variety of curriculum contents! Certainly we can acknowledge the commonalities, but we should also stress the need for differentiation.** Is it not better to accept a certain amount of variety to insure that we all don't go down together if we are wrong? It is the role of the CBE to find these commonalities and expound upon the differences.

There is no question that we can define items in the biology curriculum that are truly international. However, we must maintain and encourage variety in our curricula, both in terms of content and approaches. But, is there not a core set of understandings for students of the world upon which we can agree—a body of content knowledge and skills that, if students don't know upon "graduation," they are not yet biologically literate? Is there a right way to define the core? Possibly variety is best left to describing how best to teach the core.

We have heard the African perspective. They emphasize biology as it relates to public health, and they stress answers to questions related to how to increase agricultural production. They have already discarded concepts like evolution that are not rooted in the current problems of the culture.

It is always precarious to look into the future, but we must, for it will enrich our curricula and enable us to teach our students methods for looking into their own futures. It is important that today's students know how to extrapolate and draw scenarios related to possible outcomes.

Comment ... We have no option but to have our political, economic and social issues influence our science. Questions of bioethics relate to economic issues. We must try to teach students how to think about ethical issues, not just explore the issues themselves. The Commission must look into these issues. We must be sure that every child has an opportunity to acquire process skills. Problems of survival

take precedence over learning about evolution and some other basic biological concepts.

Teaching must be relevant to lives of students now and in the future.

Contributed Papers

The following papers were submitted to Symposium organizers for consideration by those preparing continent reports. The papers have been edited to focus on the elements of core content identified by the authors. The format below was sent to all authors to guide their reports and insure greater comparability among papers.

IUBS/CBE 1992 Call For Papers

Papers should define your country's view of what students should know and be able to do in biology/life science at various levels of precollege instruction. Try to specify the content and process goals that your country has identified and describe to what extent these have been attained. The following is a suggested outline for organizing your paper so that conference participants are better able to compare countries/continents when exploring commonalities and differences.

I. The degree to which country curriculum standards/goals have been identified and implemented.

II. Specific content/process goals --i.e. what should students know and be able to do upon completing their course of study (state outcomes that are independent of curriculum used).

A. Elementary level (approximate ages, 5-12)

B. Secondary level (approximate ages, 12-18)

Do not describe a particular curriculum or syllabus per se but rather define your country's educational goals/outcomes in such a way as to not prescribe a single method of teaching and learning strategy in the classroom. Focus on both knowledge and skills.

III. Consensus that exists as to the value of these goals/outcomes and the mechanisms your country has established for updating and constantly reevaluating these goals and objectives.

IV. Success (or lack thereof) of implementing these national goals and objectives.

A. Acceptance by teachers, students, parents, etc.

B. Availability of appropriate instructional materials

C. Teacher preparation

D. Provision of opportunities to learn

E. Other.

Contributed Paper

Biology Teaching to School-Age Students in Kenya

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Introduction

Formal education was introduced into Kenya at the turn of the century, when missionaries established schools around churches. Religion played a major role in shaping the education of most pupils and, only later, did the government play a role in influencing education.

Biology as a subject was not introduced in Kenyan schools until the late 1940s — and then only in boys' schools. In the late 1950s, a couple of girls' schools introduced the science of biology. Dramatic expansion of biology teaching in schools occurred only after independence in 1963. Today, all schools under government management or supervision teach biology or biological sciences both at the primary level (in the first eight years of school) and in high school.

New Approaches in Education in Kenya

Kenya has in the last six years undertaken extensive reorganization of the entire education system. The new system allows 12 years of learning before university entrance. Revision of the education system was prompted by the need to give an applied approach to learning and thereby prepare students for employment directly from school.

According to the new system, education is to relate closely to socioeconomic advancement and provide opportunities for the majority of school-age students who may not proceed to higher learning institutions such as universities and colleges. Thus, topics such as woodwork, metalwork, building construction, power mechanics, drawing and design are taught alongside more traditional subjects, such as history, geography, etc.

Biology Teaching in Primary School (Ages 5–13)

In primary school, biology is integrated with other science subjects. Science teaching gives students basic scientific knowledge and practical skills, such as problem solving, where students are encouraged to identify problems and design their own investigations to provide solutions. Skills of observation, measurement, recording, formulation and communication are explained, and analysis of results, interpretation and rational conclusions are encouraged on an individual basis. Information seeking methods are also highlighted to enhance further knowledge in the study of science. Observations focus on how plants, animals, and mineral and human resources are utilized at the community level.

Public health issues are taught through observations and recording of health practices in relation to a community's diseases, water, eating habits, food storage and handling, and housing and sanitation. Methods of practicing personal hygiene, such as sanitary practices, balanced diet and clean environment are taught. Students are exposed to the importance of preventive measures in the promotion of personal health, including vaccination, clearing of bushes, and the use of mosquito nets and spraying. Diagnosis of common diseases and the methods for the control of health hazards are demonstrated.

Agriculture is given great prominence in primary school teaching, where it is taught as a separate subject from science. The objectives are:

•To demonstrate through practical experiences that agriculture is a profitable and honorable occupation.

•To create awareness of the importance of agriculture in the daily life of various communities.

•To give pupils agricultural knowledge and skills relevant and useful to their lives.

•To stimulate interest and develop positive attitudes leading towards active participation in agriculture.

•To insure that schools take an active role in rural development by integrating agricultural activities in the school curriculum.

•To develop self-reliance, resourcefulness, problem solving and an occupational outlook in agriculture.

Specific Areas in Biology Teaching in Primary School

In all the activities of biology teaching at the primary school level, the learner is expected to collect, record, interpret and communicate information for rational decision making. The following themes are covered in primary curriculum:

Living Things... Differences between animals and plants, classification, behavior of animals, feeding habits and care of animals, structure and functions of animal and plant parts, growth and reproduction in animals and plants, body systems, seeds and germination, pollination and fertilization, and plant and animal processes.

Health Education ... Simple first aid, body parasites, care of teeth, human nutrition, balanced diet, deficiency diseases, drug abuse, communicable diseases, sexually-transmitted diseases.

Soil ... Composition, types and profile of soils, erosion, drainage, fertility, weathering.

Environment ... Pollution, conservation, recycling of waste.

Agriculture ... Land use, water resources and conservation, livestock and crop production, trees, soil erosion and conservation, weather and climatic factors, plant and livestock diseases, farm accounts and marketing, farm machinery and chemicals.

Assessment Strategies

In order to achieve the objectives of science teaching in primary school, teachers are expected to carry out continuous assessment. The criteria used to assess pupils are:

Observation ... Teachers observe pupils at work, both individually and in groups; assess the finished products; and award marks. In this way, the teacher is able to check on the skills acquired and the attitudes developed.

Oral Questioning... Where thinking is evoked, oral questioning is a useful technique for developing reasoning and enhancing a teacher's ability to evaluate.

Written Tests and Evaluation ... The teacher should always mark pupils' written work and go over corrections with them.

Project Work ... Working either individually or in a group, project work becomes effective only when assessed and awarded marks.

Framework of Biology Teaching in Secondary School

Under the old system, biology teaching was largely classical with emphasis on traditional aspects of the taxonomy, ecology and physiology of plants and animals.

In the new system, biology concepts have been broadened and made more applicable to real-life situations. Emphasis is placed on the understanding of biological processes and how they may be analyzed and evaluated. A problem-solving approach is taken where practical investigations through projects, discussions and laboratory experiments are conducted. According to the current high school biology curriculum, the learner is expected to:

•Develop an understanding of the relationships between plants and animals.

•Develop an understanding between man and the environment.

•Apply the knowledge gained to improve and maintain the health of the individual, the family and the community.

•Make use of locally available materials and information in improving the quality of life.

•Relate and apply relevant biological knowledge and understanding to social and economic conditions in rural and urban settings.

•Recognize and observe features of familiar and unfamiliar organisms, record observations, and make deductions about function of the whole organism and/or its parts.

•Develop positive attitudes and interest towards biological sciences and relevant practical skills.

•Demonstrate resourcefulness, relevant technical skills and scientific thinking in familiar and unfamiliar situations.

•Design, carry out and evaluate experiments and projects.

•Create an awareness of the value of cooperation in solving problems.

Teaching Strategies for Biology in Secondary School

In high school, more than half the time in the teaching of biology is spent on practical classes. Locally available plant and animal material is utilized. For example, in the teaching of ecology, a project may be undertaken in any location accessible to the school and may include the habitats — forest, grassland, marine or freshwater data. A report is written taking into account aims of the study, methodologies, interpretation of results and conclusions.

An environmental study may involve looking into factors within the school compound. Environmental parameters, such as temperature, humidity, pH, water content, wind velocity and light intensity, are measured, and issues of pollution, conservation, energy and deforestation are discussed.

In agriculture, students involve themselves practically in all processes of food production, such as preparation of land, planting, applying fertilizer, weeding and harvesting. The important aspect of marketing is included in the activity, as are issues concerning finances. Visits to various institutions, such as research laboratories, are encouraged. Here the students are exposed to application of biological systems in the production of food, improvement of health, and conservation of the environment.

In all cases, a problem-solving approach is utilized.

Evaluation of Biology Teaching

Evaluation of the implication of the new system as a whole is being undertaken. Complaints have been received that the system is too demanding and overloaded, and as such does not allow time for knowledge assimilation. This is clearly demonstrated in sciences where three-fourths of students taking final examinations at the end of high school training obtain lower than a C grade (50-60%). Further concern has been raised at the university level where performance in science-based faculties has shown weakness.

Teachers complain of a heavy work load and little incentive. Similarly, parents are concerned that the system is burdening all. To make the system more effective, the Kenya Institute of Education (KIE) has embarked on a serious review of the content, particularly with regard to the amount and depth of information.

For biology teaching, constraints in the system include lack of appropriate laboratory facilities, books and competent staff. Teacher preparation is inadequate, and more instruction time is needed for it to be effective. Steps are being taken to reduce the student load, equip laboratories, and train more teachers in science-based subjects.

A positive outcome of the new system is that a significant number of students are finding it possible to gain self employment in a scheme locally named "Jua Kali," meaning "working outside in the hot sun." As for biology, it is hoped that skills gained in agriculture and environmental biology will lead to higher food and horticultural production while, at the same time, promoting environmental conservation.

Contributed Paper

An Overview of Basic Biological Concepts for Today's School Children in Nigeria

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Introduction

Within the last quarter of this century, in all parts of the world, science and science education have come under public scrutiny. Everyone is asking what is science and what should be the goals of science and science education.

Several world international and national conferences have been held on the status and role of science. One such conference was held in 1986 in Bangalore, India, with the theme "Science and Technology Education and Future Human Needs." This conference heightened the awareness of participants to the need for rethinking the curriculum and teaching (both theory and practice) of the various science disciplines. The message was clear that science should serve to protect the planet Earth and ensure the survival of humanity.

The realization of this need to preserve and protect our environment elevated biology to a position as a core science subject. New development of interdisciplinary science areas, such as biochemistry, biophysics, biostatistics, biogeography, environmental biology, and sociobiology, bear evidence to the central position of biology as a science discipline that has much to contribute to national development and survival.

In Nigeria, a developing country, biology more than any other science subject has undergone significant modifications, both in curriculum and in teaching. Some of the topics that have emerged in recent times in school biology curricula include: population growth, over-population, food and agricultural production, health maintenance, and environmental issues such as pollution. It is argued that the evil effects of scientific practices plaguing the advanced countries must be avoided so as not to compound our economic problems with a threat to our biological survival.

It is in the context of this understanding and that of the problems of survival faced by living organisms all over the world that I have examined and proposed basic biological concepts that the world's children should know. Rather than call them concepts, I prefer to refer to them as "themes."

Basic Biological Themes

1. Inquiry Process/Scientific Investigations

Children must be introduced to the methods and tools biologists use in investigation. The focus should be on scientific method, experimentation and acquisition of science process skills.

Justification: Learners will be taught to not only appreciate how new biologic knowledge is generated but also be able, as budding biologists, to question biological principles and learn to develop new insights.

Teaching Approaches: A major teaching strategy should be the practical/experimental approach whereby pupils are presented biological problems and encouraged to carry out investigations using laboratory or field facili-

ties under the guidance of the teacher. Problems that have relevance to the students' daily lives are preferred (e.g. water purification, or the biology of weevils or any plant pest). Group work should be encouraged.

2. Food & Agriculture

Students should study the value of food and nutrition, the nature of common food and production processes, agricultural processes (e.g. cultivation, harvesting and preservation), and food distribution and shortage.

Justification: Such a study is necessary to help students appreciate the importance of food production/distribution and agriculture to the survival of humanity. Important specific objectives include development of functional knowledge of agriculture, appreciation and respect for farmers, and increased awareness of careers in agricultural fields.

Teaching Approaches: Strategies could include practical farm work in school farms; demonstration of common farming techniques; and visits to large-scale farms, including poultry and fish farms. A group project on classification of food and quantification of food should be conducted, and pictures and films could be used to show effects of malnutrition. Discussion on food distribution within the country, in the subregion of Africa, and in the world at large should be conducted. Expository method can be used to introduce innovative agricultural practices.

3. Structure & Physiology of Selected Organisms

One recognizes the numerous kinds and diverse nature of living organisms. The life cycle of some have greater effect on human survival (directly or indirectly) than others. In Nigeria, for instance, the mosquito, guinea worm, plant pests (insects) and microbes are of great relevance, and their biology has to be studied. The point is that organisms selected for study must be relevant to the country.

Students should study the cell and its environment, the structure and physiology of microbes and their activities, and the basic living processes of respiration, excretion, etc. They should also focus on the structure and function of selected higher organisms (i.e. those of economic importance) and human biological structure and processes.

Justification: There is a need for children to understand biological systems and how they function, including their own bodies. They have to acquire knowledge of the form and function of organisms whose life operations affect human survival.

Teaching Approaches: Expository methods, as well as demonstration and practical experimental methods, are recommended. For example, the teacher can carry out dissection to demonstrate the internal structure of an organism. He/she can set up experiments on the respiration process and on the growth and activities of microbes. The teacher can use expository method in addition to other strategies to teach digestion or circulation in humans. A research project is also recommended.

4. Ecology & Environment

Students should study habitats and the interactions and interdependence of living things in nature. The nutrient cycle should be taught, as well as how to maintain and manage the environment (especially pollution). Population problems should be a focus, along with the conservation of natural resources.

Justification: Though humans seek to survive first and foremost, their survival rests on understanding the interdependence in nature

and the interactions among various living organisms, and between them and the abiotic part of the environment. It becomes absolutely necessary that students of biology understand their environment and that their survival depends on maintaining the balance in the environment; learn and address bioethical and biosocial issues, such as population growth, pollution, desertification, etc.; and recognize their role as responsible citizens to conserve and preserve nature through efficient management of resources and maintenance of a clean environment.

Teaching Approaches: A popular approach to sensitizing students to ecological problems so that they want to learn more and acquire skills in ecological studies is through visits to places where they will have vicarious experiences (e.g. polluted streams, overcrowded communities, erosion sites, zoos and parks). Other approaches include group discussions on birth control and child spacing, industrial waste disposal, etc. Use of films and videotapes will add to the experiences. Research projects carried out by students are appropriate. Simulation of problems of a large family and the effects on nutrition, education and quality of life can be used. Experiments using a bacteria colony to demonstrate overpopulation are also appropriate.

5. Nutrition & Health

A basic need of living things is to feed in order to live, hence nutrition and health should be taught together in biological studies. It is important to teach basic ideas about nutrition and a balanced diet, as well as ways of improving food products and nutrition. Common tropical diseases — malaria, scabies, typhoid, etc. — should be covered, including information on how these relate to personal hygiene and health. Community hygiene and health must also be studied.

Justification: The need to maintain good health above all things needs no justification. Good nutrition and maintenance of personal and community hygiene form the basis for sustenance of life. The theme of nutrition and health will help students to develop functional and relevant knowledge of health problems and to apply such knowledge in daily life, to understand how microbial activities can impair life, and to recognize how each person's health practices affect the health of the community.

Teaching Approaches: Practical/experimental approaches should be used, such as in the case of culturing microorganisms. Field trips to health centers and hospitals are encouraged, as well as group discussions on the formation of good health habits. Written projects/essays should be assigned on such diseases as cancer, TB, AIDS, STD, diarrhea, etc., noting causes, prevention and cures. Expository method can be used to introduce students to new information.

6. Genetics & Heredity

Students need to study variation, variability among organisms and heredity.

Justification: The perpetuation of organisms and species is a natural phenomenon. Similarly, variation among organisms, even with the same parents, is a commonly observed phenomenon. The way species perpetuate, as well as explanations for variation among organisms, is an important area in biology education that children must know. Specifically, students should be able to recognize the need for continuity of life through reproduction; develop a functional knowledge of the application of genetics to agriculture, medicine for human survival, etc.; appreciate and explain the variations and differences among species members and among living things; under-

stand themselves better as individuals with specific traits; and foster respect and appreciation for individual differences.

Teaching Approaches: Practical work on leaves of different lengths and persons of different heights, colors and fingerprints should be encouraged to show variations. Practical work can be done on cross breeding in maize and animals (such as guinea pigs, chickens, etc.), as well as making models of chromosomes, DNA, etc. Group discussions on heredity, traits, sickle-cell anemia, etc. are appropriate. Expository method should be used to introduce children to new concepts.

Conclusion

Among the major problems in Nigeria today, food shortage, malnutrition, diseases and superstition/scientific illiteracy rank highest. There is an urgent need to save lives through increased food production, preservation and distribution; through proper education on nutrition and health; through education in scientific methods of inquiry dealing with cause and effect; and through using biology and other sciences to address societal issues.

Bybee (1983, p. 7) presented the following goals of biology education:

- "to develop a fundamental understanding of, and the ability to use, the methods of scientific investigation;
- to prepare citizens to make responsible decisions concerning science-related issues; to contribute to an understanding and fulfillment of personal needs and, thus, contribute to the development of the individuals; and
- to inform students about careers in biological and health science."

In summary, Bybee states that biology education must seek to improve knowledge of biology science processes, social issues, personal needs and career awareness. Each country puts different emphasis on each of these goals, but the goals are the same worldwide. In Nigeria, biologic knowledge and science processes appear central to the curriculum; however, recently important social issues, such as drug use/misuse, pollution, environment, killer diseases, etc., are being included. Much emphasis is placed on ecology since this area is integrative in nature and essential for survival within the changing environment. To sum up, biology concepts that children of today need to know have to be those that will enable children to meet their daily needs and ensure survival.

References

Bybee, R. (1983). *Focus on excellence.* In J.E. Penick and R.J. Bonnstetter, (Eds.). Washington, DC: NSTA.

Champagne, A.B. & Horning, L.F. (Eds.). (1987). *The science curriculum.* Washington, DC: AAAS.

Federal Ministry of Education. (1985). *Biology curriculum for senior secondary school.* Lagos, Nigeria: Federal Ministry of Education.

Okeke, E.A.C. et al. (1983). *Biology for senior secondary school.* Ibadan, Nigeria: Science Teachers Association of Nigeria, Publc., Heinemann Educational Books Nig. Ltd.

Penick, J.E. & Bonnstetter. R.J. (Eds.). (1983). *Focus on excellence Vol. 1 - No. 3 biology.* Washington, DC: NSTA.

Rao, A.N. (Ed.). (1987). *Food, agriculture and education.* Pergamon Press.

Contributed Paper

Biology Curricula Standards for Content & Teaching in the Near East

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Introduction

In the Near East region, "standards" are understood to be "the most common prevailing content and teaching practices in the region, in light of what should be." The purpose of standards is to try to help promote a central set of concepts, teaching strategies and assessment procedures at the precollege education level.

Content

A. Organization

Biology concepts are taught all through the years of general education. Biology is integrated with other sciences in the primary and intermediate school except for one or two countries where it is taught separately at the intermediate level. Biology is taught as a separate subject in the secondary schools. In most countries, it is taught every year during the three years of secondary school.

Until 1974, biology was taught as botany and zoology, and then the influence of BSCS from the U.S. resulted in introduction of an integrated biology course. Although very few countries adopted the Biological Sciences Curriculum Study (BSCS) program in its entirety, some did adapt it to their needs. French-speaking countries in North Africa were also influenced by the French biology curricula. Moreover, the pilot project to improve biology education in the Arab States, which started in 1972, represented a turning point in helping to improve biology curricula for 22 countries in the region.

B. Approaches

The environmental approach is used in some courses, and the molecular approach is used in others. Social implications of biology are emerging but are not fully integrated into the basic curricula of most countries.

C. Scope & Sequence

In the first nine grades (primary and intermediate), biological concepts are integrated with other courses, such as nature study or integrated science. The human body, its systems, and some information about nutrition, plants, flowers, fruits, pets, insects and diseases are dealt with in the primary school.

At the intermediate level, many countries implement the integrated science curriculum started by the Arab League Educational, Scientific and Cultural Organization (ALESCO) in the late 1970s. The curriculum is environmentally oriented, and biology is offered as part of the content dealing with the biosphere; adaptation to environmental conditions; web of life; the food chain; agriculture; health; the unit of living organisms — cells, insects and disease; pollution; etc. There is no sequence for biology topics at that level.

Biology as a separate subject starts in the secondary schools in most countries of the region. There is usually a theme for every grade that determines the scope of the concepts and principles taught.

In Grade 10, the theme is "Biology and the

Biosphere." The main topics dealt with are: What is biology? — Historical achievements of eminent biologists, discovery of malaria, Bilharzia, vitamins, etc. ... Study of two ecosystems — land and water ... Adaptations of plants and animals in different ecosystems ... Relationship between and among organisms ... Man and his impact on the environment ... The Earth as an ecosystem ... Why classify living organisms? ... Environmental factors affecting organisms.

When the content at this grade level is analyzed, it is found that the following concepts and principles are covered:

Biology — parasitic worms (Bilharzia), infection, preventative medicine, the cell and its components (plant and animal cells), types of plant tissue, homozygous, heterozygous.

Differentiation of animal tissues — heredity — inheritance of some human traits — complete dominance — incomplete dominance — chromosomes — sex determination — classification of plants and animals — predation symbiosis — parasitism — scavenging — commensalism — energy pyramid — mutualism — energy flow — food pyramids — producing organisms — consumers — food chain — natural pollutants — air pollution — water pollution — solid pollution — plant production — plant pests — horticulture — marine resources — energy problem — drought — desertification — environmental equilibrium — pollution of the environment.

In Grade 11, the theme is "Unity and Diversity" among living organisms. The topics covered include: Concept of the cell and its contents and functions (except reproduction which is treated in Grade 12) ... Nutrition ... Transport ... Excretion ... Movement ... Hormonal coordination ... Digestion ... Respiration ... Support ... Sensation.

A content analysis of instructional materials reaffirms that the following concepts and principles are taught:

Nutrition — absorption — structure — osmosis — photosynthesis — chloroplasts — osmotic pressure — structure — mechanisms of photosynthesis — nutrition in unicellular organisms — invertebrates and vertebrates — digestive system in man — insectivorous plants — enzymes — digestion — transports in higher plants — capillarity — vascular system — transport in hydra — open circulatory system — circulation in man — blood systems of a rabbit — aerobic respiration and anaerobic — respiratory systems in insects — respiration in plants — excretion and systems — support in plant and animals — motion in plants and animals — sensation — nervous system — glands — hormones.

In Grade 12, the theme is "Perpetuation of Life." Main topics include: The cells ... Reproduction and development ... Differentiation and specialization of cells ... Heredity ... Continuity of life ... Diversity and adaptation ... Variety of life in the past ... Mechanism of evolution ... Improving future life on the basis of biological concepts.

A content analysis of instructional materials reaffirms that the following concepts and principles are presented:

Reproduction (sexual and asexual) — cell divisions — classification of flowering plants — pollination — fruits and seeds — seed dispersal — germination — reproduction in animals — population explosion — reproduction in man — homozygous and heterozygous individuals — complete and incomplete dominance — examples from

man — genes — lethal genes — chromosomes — nucleic acids — code ribosomes — mutation — sex-linked characters — environmental factors — DNA — RNA messenger — biotechnology evolution — evolution theory and the origin of life — classification — fossils — Lamarck and Darwin theories — virus — bacteria — inherited immunity — natural selection — mutualism.

Concepts can be taught at various levels of sophistication — from the concrete, through the transitional, and ultimately to the abstract. Research has shown that in some countries there is not much distinction made among the levels of concept understanding, and no effort is made to relate this to a student's mental development. Also, biology content is not usually tailored to meet the needs of the learners and the society.

Table 1. Responses of the sample as to the degree of importance of teaching some bioethics topics in secondary schools of Egypt.

	Degree of Importance		
	Very Imp. %	Imp. %	Not Imp.%
1. Starting ova and sperm banks.	12	23	65
2. Artificial insemination from donors.	7	21	72
3. Surrogate mother.	11	26	63
4. Predetermination of fetal sex.	11	22	67
5. Test-tube babies.	8	18	73
6. Research to extend life span.	10	22	68
7. Human organ banks.	14	32	54
8. Genetic engineering for bio. warfare.	17	33	50
9. New individuals through bioeng.	9	20	71
10. Fetal freezing.	9	19	72
11. Mercy killing of uncurable cases.	10	20	70
12. Genetic screening.	8	20	72

Update

There is usually a time lag between biology discoveries and their introduction in the curriculum. In some countries, the lag time is short, but in most Near East countries, it is rather long. Sometimes teachers resent changing the content of their courses. This has happened in many cases, e.g. when the source of oxygen in photosynthesis was discovered and when biotechnology was introduced.

Teachers as well as parents resent the teaching of some bioethical issues. For example, in a study conducted in Egypt, 12 concepts were presented to a group of 175 highly educated individuals who were asked to rank the importance of certain concepts in the biology curriculum. The majority resented teaching such concepts. Results are shown in Table 1.

When the same concepts were presented in a negative way with an emotional bias, the majority changed their response and approved teaching the concept.

Results are show in Table 2.

Teaching

Teaching of biology in this part of the world is very traditional. Emphasis is more on memorization of facts, and the lecture is the predominant teaching method. There is not much emphasis on other important higher levels of achievement and mental processes — critical thinking and decision-making. This is also common in the teaching of other disciplines.

In most countries of the region, practical work in biology is limited, as is field work. Any experiments are demonstrated by teachers, rather than involving students in the process of science.

Evaluation

Examinations are the main tools of assessing students' progress in biology. Rote learning of facts and information is stressed.

	Degree of Importance		
	Very Imp. %	Imp. %	Not Imp.%
1. Dangers of sperm and ova banks.	88	12	0
2. Bad sequences of artificial insemination from donors.	100	0	0
3. Risk of surrogate mothers.	68	32	0
4. Unethical predetermination of fetal sex.	100	0	0
5. Risks of test-tube babies.	100	0	0
6. Stupidity of research to extend life span.	100	0	0
7. Hazards of human organ banks.	100	0	0
8. Horrors of genetic engineering for biological wars.	100	0	0
9. Unethical creation of new individuals through bioengineering.	72	28	0
10. Risks of fetal freezing.	60	33	7
11. Criminal mercy killing of uncurable cases.	30	37	33
12. Dangers of genetic screening.	92	8	0

Table 2. Responses of the same sample as to the degree of importance of teaching some issues using value-laden language.

The way examinations are constructed and administered is responsible for not stressing other vital objectives of biology education, i.e. skills and attitudes. Few schools test skills by asking students to conduct a simple experiment and/or identify some specimens and apparatus.

Contributed Paper

Biology Teaching & Its Contents in Japan

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General Scope of Japanese Education & Its System

After World War II, the organization of the various Japanese public institutions and systems underwent drastic changes. The educational system was also reformed: The "multi-track" system was changed into a "single track" system that provided equal opportunity for all and prohibited discrimination on account of race, creed, sex, social status, economic position and family origin.

The present Japanese educational system is patterned mainly on the 6-3-3-4 system — six years of elementary school, three years of lower secondary school, three years of upper secondary school, and four years of college and university. Elementary and lower secondary schools provide compulsory education for children from six to 15 years of age.

Upper secondary schools are not compulsory and only admit those who have passed entrance examinations. The rate of enrollment in upper secondary schools is increasing year after year. It is about 95% of the age group at present, so even though it is not compulsory, the high percentage of enrollment in upper secondary schools makes it look compulsory.

A uniform education is given during compulsory education, but at the upper secondary level schools are classified into "general" and "vocational" (agricultural, industrial, business, etc.). Students select subjects, and only a few subjects are required of all students. Therefore, the curriculum is not uniform in the upper secondary schools.

The Curriculum Requirements, Standards & Textbooks

The requirements and standards of curriculum are established by the Ministry of Education, Science and Culture with the advice of the Curriculum Council. The Course of Study issued by the Ministry outlines the basic framework for all curricula, including the goals, objectives and content of each subject at each grade.

It is set by law that:

•The literature allowed to be used in Japanese schools as teaching materials should be only those textbooks authorized by the Ministry of Education, Science and Culture.

•Each student should have his/her own copies of the textbooks.

•Other literature may be used as teaching reference books after receiving permission from the prefectural or municipal board of education.

The textbooks are written and edited privately. The number of pages, font type and its size, the number of lines per page, the price, and the like are regulated in detail by the Law Governing Provisional Measures on Publication of Textbooks and the Regulations for Textbook Authorization.

Samples of printed textbooks are submitted to the Ministry of Education, Science and Culture by the textbook publishing companies after they have been written and edited. The Ministry will then pass them to the Textbook Authorization and Inspection Council for in-

spection as to whether or not the textbooks agree with the intent of the law and with the contents of the Course of Study and whether or not the books are suitable as textbooks. Based on the reports from the Council, the Minister makes final decisions. As a result, there is little difference in content among textbooks finally authorized.

Revision of the Course of Study

Revision of the Course of Study is done every 10 years or so. The Course of Study was revised in 1978, and the latest revision was in 1989. The textbooks in use in 1992 in lower and upper secondary schools are those authorized under the 1978 Course of Study.

The special feature of the 1989 revision was to gear education towards meeting the demands of an industrialized society and satisfying the needs of the highly information-oriented society of the 21st century. The central idea was to change the uniform type of education that has been given in the past to that which emphasizes the importance of the individuality of the learner and encourages students to be creative and to think independently. As a result, there has been a big change in the objectives of school education. This, in turn, has caused a change in the objectives and contents of each subject.

Before the reform, "Science" had been taught from the first grade on, but beginning in 1992, the subject "Science" is not now taught until the third grade due to the revision of the Course of Study. The objectives of "Science" and the goals and contents of the biology-related components are discussed later in this presentation.

In lower secondary schools, the subject matter of "Science" is divided into two areas: the first area covers physics and chemistry, and the second area covers biology and earth sciences. The objectives of secondary science, excluding the area related to the earth sciences, are outlined later in this presentation.

At present, upper secondary science is taught in six subjects; namely, Science I, Science II, Physics, Chemistry, Biology and Earth Sciences. Science I is a required subject that all students have to take in the first year (10th grade) of upper secondary school. Other subjects are electives, out of which each student is required to take two subjects during the second and the third year. Science I is a four-credit-hour course consisting of materials from physics, chemistry, biology and earth sciences, the contents of each area being equivalent to one-credit-hour course material.

Based on the 1989 revision of the curriculum, starting from 1994, the subject "Science" will be divided into five sub-subjects: Integrated Science, Biology, Earth Sciences, Chemistry and Physics. As of 1994, there will be no one science course that all students are required to take at the upper secondary school level. Instead, students will be able to select any two "Science" courses.

At the introductory level for each science, there is a "Track A" and "Track B." For example, "Integrated Science" is a subject designed to enhance student knowledge and understanding about the natural environment from a broad perspective. Courses with a subtitle "A" will cover topics related to daily life and their application to scientific and technological development. Courses with a subtitle "B" and all higher-level courses will focus on the more basic concepts of the natural sciences.

Science and technology colleges and universities usually require their applicants to select

and take examinations in two science subjects along with a few other subjects in nonscientific areas. Since it is generally believed difficult to get very high scores in biology and earth sciences, these two subjects are less favored as subjects for the entrance examination. As a result, many students enrolled in biological sciences faculties and departments, including agriculture and fishery, have not studied biology in upper secondary schools. Since the university cannot require specific subjects for students to take at upper secondary schools, the large number of students with no high school biology who are enrolled in biological sciences departments at the university level is causing a big problem.

The abolishing of Science I after 1994 will produce a large number of students who have not studied biology at all in upper secondary schools. Even if biology has been studied, the scope of the content will be greatly different between "A" and "B" courses since the goals and contents of these two are completely different. Thus, from 1994 on, the biology content guaranteed to have been studied by every Japanese student will be limited to that learned during the compulsory education period up to 15 years of age.

Problems for the Future

The underlying reason for the curriculum revision in 1989 was the criticism that upper secondary "Sciences" placed too much emphasis on acquisition of knowledge and memorization of information. Because of this, many students did not comprehend the content and developed a dislike of science.

The 1989 revision of the Course of Study focused on cultivating interest in science through observation and experiment. The new science education started in elementary schools in 1992 and begins in lower secondary schools in 1993 and in upper secondary schools in 1994. Nevertheless, it will be some years before the fruit of this change is seen in schools.

ELEMENTARY SCHOOL SCIENCE
(Biology-Related Contents)

Objectives

•Gather firsthand experience with the natural environment.
•Observe and experiment in order to cultivate problem-solving ability and love of nature.
•Develop understanding of nature and natural phenomena.
•Develop a scientific view and way of thinking.

Goals & Contents by Each Grade
(Third Grade)

1. Goals

To compare plants and animals in the neighborhood and to study the human body ... to develop respect for living things and foster understanding of body structure and the growth process of living organisms using inquiry activities.

2. Content

•To study the processes of growth and structure of plants through collecting and raising plants in the neighborhood ... to investigate plants' growth processes, i.e. that a new life starts either from a seed, from a root, or from a stem ... to discover that a plant body is made up of a root, stem and leaves, and different plants have their own peculiar structures.

•To study processes of growth and body structure of insects through collecting and raising insects in the neighborhood ... to investigate the various stages of an insect's growth and to discover that food is needed by different species and by the same individual at different

growth stages ... to discover that an insect body is made up of a head, a thorax and an abdomen, and that different insects have their own peculiar structures ... to study the human body through observation and comparison with bodies of other animals ... to learn that different parts of the human body — like eyes, ears and skin — have their own unique functions ... to learn that bones and muscles enable man to move his body.

(Fourth Grade)

1. Goals

To observe plants and animals in the neighborhood and learn how the human body relates to weather and time of day ... to develop respect for living things and foster understanding of activities, growth and relationship between environment and living organisms through inquiry activities.

2. Content

•To study plant movement and growth and its relation to the environment through collecting and raising plants in the neighborhood ... to discover that plant movement and growth processes are influenced by weather and time of day ... to investigate how plant growth is affected by changes in the seasons, e.g. warm season, cold season.

•To study processes of animal activities and their relation to the environment through collecting and raising animals in the neighborhood ... to investigate how animal activities are affected by weather and time of day ... to investigate how animal activities are affected by season, e.g. warm season, cold season and the like.

•To study the relationship between human activities and the environment through observing and comparing human activities with those of other animals ... to discover that human pulse and temperature change through activities but are kept fairly constant after lying quietly for some time ... to discover that man's activities are influenced by the season and time of day.

(Fifth Grade)

1. Goals

To observe development and growth of living organisms with special attention to the conditions affecting them ... to solve problems, develop respect for life, and foster thinking about continuity of life through inquiry activities.

2. Content

•To study the mechanism of germination, growth and fruition through raising plants ... to discover that flowers have stamens, pistils and other parts, and that when pollen gets on the stigma, fruition takes place, and the plant bears seeds ... to discover that plants germinate using the nutrient substance in the seed and that their growth is affected by the sunlight, fertilizers, etc.

•To study development and growth of fish and other small animals through raising them ... to discover that there are male and female animals and that some of them are hatched from eggs, while others are born live ... to discover that the embryo inside the fish egg undergoes changes as days pass, a fish comes out, and then feeds on small living organisms in the water.

•To study birth and growth of humans through comparative observation of man and other animals and use of various materials ... to discover that physical characteristics of men and women are different ... to discover that human growth starts within the mother's

womb, and the baby is born when a certain stage of growth is reached.

(Sixth Grade)

1. Goals

To observe the functioning of living organisms, body structures and their relationship with the environment ... to solve problems, develop respect for life, and foster critical thinking regarding the commonality of physical makeup and functioning of living organisms in relation to their environment.

2. Content

•To study water passage within the plant body and the function of leaves by raising plants ... to discover the paths for water and nutrients in roots, stems and leaves (water absorbed by roots evaporates mainly from the leaves) ... to discover that starch produced in the leaves under the sunlight is needed for growth and is stored in potatoes or seeds.

•To study functions such as respiration, digestion, excretion and circulation through the observation of the inside of the animal body ... to learn that animals take oxygen into their bodies and excrete carbon dioxide ... to learn that food is digested and absorbed as it passes through mouth, stomach and bowels (what has not been absorbed is excreted) ... to learn that blood circulates throughout the body, is pumped by the heart, and carries nutrients, oxygen, carbon dioxide, etc., to all corners of the body.

•To study characteristics of humans and their relationship with the environment by comparing and relating the human body with other animals and plants ... to discover that some of the physical makeup and functions of the human body are similar to other animals and that others are different ... to learn that human beings depend on other animals, plants and the environment that surrounds them for food, water, air, etc.

LOWER SECONDARY SCHOOL SCIENCE (Biology-Related Contents)

Objectives

•To promote interest in nature, perform observations and experiments, and foster the ability and attitude to investigate scientifically.

•To deepen the understanding about nature and natural phenomena and to cultivate a scientific way of thinking and looking at things.

Goals & Contents of Each Area

1. Goals

•To identify the questions and problems that surround natural phenomena through the process of scientific investigation . . . to discover rules that govern these phenomena . . . and to learn how to explain these natural phenomena.

•To observe and perform experiments about organisms and to acquire the skills to observe and do experiments. Furthermore, to learn about the classification of plants and animals and to understand the connections between them and, also, to foster a scientific way of looking and thinking about phenomena.

•To enhance interest in nature and the natural phenomena that surround living things and to enthusiastically investigate nature. To preserve the physical environment and to cultivate an attitude of respect for life.

2. Content

Plant Life

To observe and perform experiments about common plants and to learn the basic ways of

investigating organisms. Moreover, to understand the structure of plants and the way they function.

Physical Structure of Plant Life

•To observe organisms on the school grounds and the areas surrounding it to discover how different kinds of organisms live in different places ... to learn to manipulate observation tools and to record observations.

•To observe the flowers of different kinds of plants and use the records made during observations as a basis for discovering the basic structural features of flowers, together with how these relate to their functions.

•To observe the leaves of different kinds of plants and use the records made during observations as a basis for discovering the structural features of leaves and how these are related to the processes of photosynthesis and transpiration.

•To observe the roots and stems of different kinds of plants and use the records made during observations for discovering the basic structural features of roots and stems and how these are related to the functions of roots and stems.

Plant Classification

•To classify the physical features of flowering plants and learn methods for recognizing plant types.

•To observe non-flowering plants and, as a result, discover the characteristics of the plants.

Animal Life

To observe and perform experiments on animals in the neighborhood ... to understand the functions and structure of animals ... to deepen knowledge about animals and their lives.

Physical Structure of Animal Life

•To observe common animals and learn how the features of the animal physique influence their lives in comparison to plants.

•To observe animal blood circulation and understand that inside an animal's body there is a system for transporting various substances.

•To observe and do experiments on digestion and respiration and grasp the relation between the results of these observations and the fact that in animals there are systems for taking in substances that are necessary for their bodies and also systems for excretion of substances that are not used.

•To observe situations when animals react to outside stimulus and, thereby, grasp how these are related to their sensory organs, nervous systems and locomotory organs.

Animal Classification

•To observe the physical body of vertebrates and the manner in which they reproduce.
•To use these observations for comparisons and discover how to classify vertebrates.
•To observe invertebrates and discover their characteristic features.

The Link Among Organisms

To observe and experiment on common organisms ... to understand the evolution of organisms and the parent/child relationship and the structure of organisms at the cell level ... to deepen knowledge about the relationships of organisms in nature.

Organisms & Cells

•To observe different kinds of cells and discover that organisms are comprised of cells and that there are unique features of plant and animal cells.
•To observe cell division and understand the

connection between cell division and the growth and development of organisms.

Reproduction & Heredity in Organisms

•To observe how common organisms reproduce and to discover the features of sexual and asexual reproductions.

•Consider the results of cross experiments and discover the laws of transferring characteristics from parent to offspring.

Linkages in the World of Organisms

•Compare the features of different organisms, discover the affinity among them, and know that organisms evolve.

•Investigate the functions of microorganisms and grasp the reciprocal relationship of plants, animals and microorganisms, as far as nutrition intake is concerned. Also, to discover how organisms live and maintain balance in nature.

UPPER SECONDARY SCHOOL SCIENCE

Objectives

To promote interest in nature, do observations and experiments, and foster the ability and attitude to investigate scientifically ... to deepen the understanding about nature and natural phenomena ... and to cultivate a scientific way of thinking and looking at things.

Goals & Contents of Each Subject

(Biology 1A)

1. Goals

To do research activities concerning organisms, man and the biological phenomena that are connected with our everyday life ... to perform these activities and cultivate in students a scientific way of thinking and looking at things ... to make the students understand organisms and the phenomena related to them and also about biology and the applications of it ... to learn the relation between scientific and technological progress and human life.

2. Contents

•Human life and organisms ... everyday life and organisms, humans in nature.
•The human as an organism ... characteristics of man, behavior of man.
•Life-sustaining activities ... food and metabolism, body regulation.
•From parent to child ... lifetime of man, heredity of man.
•Progress in biology and human life ... utilization of microorganisms.

(Biology 1B)

1. Goals

To observe and experiment on organisms and the phenomena related to them and to cultivate the ability and attitude to do biological research ... to understand the basic concepts, principles and rules about organisms and to foster a scientific outlook of nature.

2. Content

•Structure and function of organisms:
—Cell ... structure and function of the cell, multiplication of cell, unicellular and multicellular organisms.
—Metabolism ... internal chemical reaction and enzymes of organisms, anabolism, catabolism.
—Research activities related to the structure and function of organisms.

•Continuity of life:
—Reproduction and development ... meiosis and formation of germ cell, reproduction and life cycle, development and its mechanism.
—Heredity and variation ... law of heredity,

genes and chromosomes, variation.
—Research activities related to the continuity of life.

•Organisms and their physical environment:
—Reaction and regulation ... reception of stimulus and behavior of animals, internal environment and its homeostasis, plant reaction and regulation.
—Population ... population and variation of organisms, ecosystem and circulation of materials, balance of nature and conservation of physical environment.
—Research activities related to the physical environment and organisms.

(Biology II)
1. Goals
To observe and do experiments on organisms and the phenomena related to them and to cultivate the ability and attitude to do biological research ... to understand the basic concepts, principles and rules about organisms ... to foster a scientific outlook on nature.

2. Content
•Biological phenomena and molecules:
—Living body function and protein ... metabolism and enzyme, biological protection and protein.
—Character manifestation and nucleic acid ... genetic information and its manifestation, regulation of manifestation.

•Evolution and genealogy of organisms:
—Evolution of organisms ... ups and downs of living world, mechanism of evolution.
—System and classification of organisms.

•Research studies on a particular organism or biological phenomenon and/or survey of the natural environment.

Contributed Paper

Biology Education in the Middle Schools in Beijing

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Introduction

The teaching of biology in junior and senior middle schools in Beijing is similar to curricula and textbooks used in other cities and provinces, with minor modifications made to fit local situations. Three biology courses are given in the junior middle schools — botany, zoology, and human physiology and health — each for one academic year. In the senior middle school, only one biology course (i.e. biology) is offered. Outlines for each of these courses follow, as well as a list of the laboratory and field work that each student is expected to do.

Considering the development of modern biology and the prevailing situation in China, the following concepts should be emphasized or added to what is taught now.

1. Biodiversity and the protection of our biosphere and environment.

•The importance of biodiversity. Human beings and all species are interdependent upon one another; the protection of the biosphere is necessary for the protection of mankind.

•The importance of the forest and afforestation.

•The danger of over-harvesting of trees and over-hunting.

•The importance of maintaining grassland, which is decreasing tremendously in China.

•The importance of water and soil conservation. China has a very serious water problem. In about 300 cities, the shortage of water is as high as 10 million cubic meters per day. This is again related to afforestration and the protection of grasses.

2. Population. Overpopulation is the most serious problem in China. The population of China is increasing at a rate of 15-17 million per year, and the arable land is decreasing at a rate of 300,000 hectares per year. The result will be the deterioration of the agricultural, ecological environment. Moreover, environmental protection is also a worldwide problem. Family planning/sex education must be stressed in China.

3. Biotechnology. From the ancient experience on various fermentation technologies to modern genetic engineering.

4. Investigative hands-on student experiments, that can be done easily and inexpensively. The laboratory work for the students of senior middle schools is especially poor and not up-to-date. Some simple experiments related to biotechnology should be added. This is particularly important in small cities and rural areas. In this respect, re-education and retraining of teachers is absolutely necessary.

5. Direct learning experiences from student interaction with nature.

JUNIOR MIDDLE SCHOOL BOTANY

Content

A. Green flowering plants

•Basic structure of plants ... the cell, tissues and organs.
•Seeds ... structure, composition, germination, dormancy and longevity.
•The root ... morphology, structure, absorption of water and minerals.
•The leaf ... morphology, structure, photosynthesis, respiration, transpiration.
•The stem ... bud and its development, morphology, structure, translocation in stem, propagation by stem.
•Flowers and fruits ... types of flowers and inflorescence, flowering and pollination, fertilization and fruit and seed formation, structure and types of fruits, the relationship between flowering and fruit setting, and the growth of root, leaf and stem.
•Taxonomy of green plants ... principles of classifying plants.

B. Diversity of plants
- Algae.
- Bacteria and fungi.
- Lichens.
- Mosses and liverworts.
- Ferns.
- Seed plants ... gymnosperms, angiosperms
- The evolution of plants ... evidence and the course of plant evolution, natural selection.

C. Plant community
•Composition and structure of plant communities.
•Geographical distribution of plant communities in China.
•Valuable, rare and endangered plant resources in China.
•Protection of plant resources.

Laboratory Work
A. The microscope ... structure and use.
B. The plant cell ... mounting of onion epidermis and observation.
C. Observation of root hair and root tip with stained section of onion root.
D. Observation of leaf structure by freehand section.
E. The formation of starch in leaves in light.
F. Stem structure.
G. *Chlamydomonas* and *Spirogyra.*
H. Bacteria, yeast and penicillum.
I. Collection and preparation of plant specimens.

Field & Home Work
A. Growing bean and maize plants from seeds.
B. Observation of the growth of roots of bean seedlings by drawing lines with India ink on it.
C. Growing wheat or buckwheat seedlings outdoors and in a dark place, and comparing the growth and color of the seedlings.
D. Observing a leaf bud cut longitudinally with a magnifying lens.
E. Dissecting and observing a flower of peach, wheat and other plants.
F. Observing the flowers of some plants belonging to the mustard family and separating them into different parts — calyx, corolla, pistil and stamen.
G. Observing and comparing the tubular corolla and the ligulate corolla of sunflower head.
H. Collecting and observing mushrooms.
I. Collecting and growing some mosses.
J. Observing male and female cones of pine trees in the spring.
K. Visiting a nearby forest and/or visiting a botanical garden, if possible.

JUNIOR MIDDLE SCHOOL ZOOLOGY

Content
A. Protista ... paramecium, amoeba and plasmodium.
B. Cnidaria ... hydra, jellyfish and corals.
C. Platyhelminthes ... turbellarian worm and blood flukes.

D. Nematodes ... roundworms and hookworms.
E. Annelids ... earthworms.
F. Mollusca ... clams and snails.
G. Arthropods ... insects (locusts, silkworms, butterflies, honey bees, house flies and mosquitoes); Crustaceans; Arachnids; and Myriapods.
H. Echinoderms ... sea stars, sea cucumbers and sea urchins.
I. Cordates
- Lower cordates ... lancelets.
- Fishes ... crucian carp and the diversity of fish; fish farms and fisheries, both freshwater and marine
- Amphibians ... frogs, characteristics and origins of amphibians.
- Reptiles ... lizards, the era of reptiles (dinosaurs).
- Birds ... pigeons, the diversity of birds; nesting, hatching and parent care; migration; bird resources and their protection in China; the origin of birds.
- Mammals ... rabbits, Monotremata and Marsupalia, Chiroptera and Cetacea, Carnivora, Perissodactyla and Artiodactyla, Primata, mammal resources and their protection in China.

J. Evolution of animals ... Evidence and the course of animal evolution, the origin of humans and the influence of human activities on the animal kingdom.
K. Geographical distribution of animals in China.

Laboratory Work
A. Paramecium.
B. Hydra.
C. Anatomy of the earthworm.
D. Anatomy of the locust.
E. Collection and preparation of insect specimens.
F. Anatomy of the carp.
G. Anatomy of the frog.
H. Anatomy of the rabbit.

Field & Home Work
A. Collection of earthworms and observation of their activities in soil consisting of different layers of sand and loam in glass bottles.
B. Observation of locusts, crickets and mole crickets.
C. Observation of moths, silkworms and butterflies.
D. Raising silkworms or other insects and observing their metamorphosis.
E. Observation of three types of honeybees and visiting a bee yard.
F. Observation of house flies and mosquitoes with a magnifying lens.
G. Observation of spiders and their activities.
H. Observation of the activities of a living carp.
I. Collection of the fertilized eggs of frogs or toads, raising them and observing their developmental process.
J. Observation of an egg (chicken, duck or pigeon), paying attention to the shell, the membrane beneath the shell, air chamber, egg white and egg yolk (yolk sac, amniotic cavity, amnion andallantois).
K. Preparation of artificial nests to attract birds.
L. Raising and observing rabbits.
M. Visiting a zoo and/or a museum of natural history.

JUNIOR MIDDLE SCHOOL HUMAN PHYSIOLOGY & HEALTH

Content
A. The human body.
B. Skin ... structure and function, health care of skin.
C. Movement system ... skeleton, skeletal muscle.
D. Circulatory system ... blood, blood vessels

and heart, blood circulation, lymphatic system.
E. Respiratory system ... structure and function of respiratory system, respiratory movement and gas exchange.
F. Digestive system ... composition and role of food, structure and function of digestive system, and digestion and absorption.
G. Metabolism ... metabolism of carbohydrates, proteins, fats, water and minerals; energy metabolism.
H. Excretory system.
I. Endocrine system.
J. Nervous system ... spinal cord and spinal nerves, brain and brain nerves, higher nervous activity, health care of nervous system, sensory organs.
K. Reproduction and development ... reproduction, development.
L. Infectious diseases ... infectious diseases in general, prevention of infectious diseases.

Laboratory Work & Home Work
A. Observation of the epithelial cells from the oral cavity under microscope.
B. Observation of sections of epithelial tissue, connective tissue, muscular tissue and nervous tissue under microscope.
C. Observation of the structure of bone and joint and understanding the composition of a piece of bone by burning and acid treatment.
D. Observation of blood, especially white and red blood cells.
E. Observation of blood stream in a frog, differentiating arteries, veins and capillaries.
F. Observation of pig or sheep heart and its internal structure.
G. Observation of the rhythmic beat of a frog heart.
H. Respiration: test of the exhaled carbon dioxide and measurement of the vital activity of lungs.
I. Digestion of starch with salivary amylase.
J. Observation of the villi of the small intestine of a pig or sheep.
K. Experiments on reflex using a frog.
L. Eyesight test and test for blind spot.
M. Examination of roundworm eggs in feces.

SENIOR MIDDLE SCHOOL BIOLOGY

Content
A. The cell ... chemical composition, structure and function, cell division.
B. Metabolism
- •Metabolism of green plants: water metabolism, mineral metabolism, photosynthesis, respiration.
- •Metabolism of animals: exchange of substances among cells, food digestion and metabolism, energy metabolism.
- •Basic types of metabolism.

C. Reproduction and development.
- •Reproduction: types of reproduction, mitosis and the formation of reproductive cells, alteration of generation.
- •Development: ontogeny of plants, ontogeny of animals.

D. Regulation of life processes: plant hormones, endocrine systems in animals.
E. Heredity and variation.
- •Inheritance.
- •Material basis of inheritance: DNA as the genetic material, structure and replication of DNA, control of character by the gene.
- •Fundamental laws of inheritance: law of segregation of genes, law of assortment of genes, law of linkage and interchange.
- •Sex determination and sex-linked inheritance.
- •Cytoplasmic inheritance.
- •Variation: gene mutation, chromosome variation.

F. Origin and evolution of life.
G. Organism and environment: organism and environment in general, ecosystem, protection of nature.

Laboratory Work

A. Mitosis of plant cell (root tip of onion).

B. Plasmolysis and deplasmolysis of plant cell (purple onion).

C. Absorption of ions by onion root (the exchange of Ca^{2+} with methylene blue that has been absorbed by onion root).

D. Isolation and separation of chloroplast pigments.

E. Polytene chromosomes in the cell from the salivary gland of a fruit fly larva.

F. Segregation of the colors of grains of hybrid maize.

Contributed Paper

Biology Education in Australian Schools

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Australian Biology Education: A Continuing Process of Change

Australian education is characterized by curriculum autonomy at state, individual school and classroom levels (Australian Education Council 1990). Three of the eight states allow individual schools to utilize a "framework" of suggested content and processes provided by the education system at the primary (elementary) and junior high school levels. The remaining five state systems prescribe topics, units or themes for the organization of learning. Within each state, however, final year certification requirements apply a significant degree of curriculum uniformity in the final years of secondary (high school) schooling. As an additional factor contributing to a diverse national system, some of the states are currently undergoing curriculum review and implementing change. This paper draws upon syllabus statements to present a summary of current primary and secondary biology education practices.

Goals of Australian Biology Education

Primary (Elementary) Biology Education

Primary science education is currently receiving some long overdue attention from policymakers and curriculum developers. Many of the new developments in secondary science education, particularly those relating to inquiry learning and contextual studies, have been characteristic of general primary education for decades but have only recently been "discovered" by the secondary community. Much quality biology education undoubtedly occurs every day in primary classrooms around the nation. Nevertheless, science, including biology, has until recently been accorded a low priority in the primary curriculum, a fact reflected in the inadequate time allocated to it in many schools.

All systems value the development of inquiry and problem-solving skills through the students' active involvement with elements of their immediate environment. The following topics and processes are common to all Australian states at the primary school level.

Content ... Animals and plants ... simple classification ... reproduction ... human health and hygiene ... ecological studies ... effects of humans on the environment.

Process ... Planning — posing questions, suggesting explanations and testing hypotheses ... collecting data — observing and describing, estimating and measuring, manipulating data ... organizing data ... generating knowledge — inferring and identifying relationships ... evaluating — identifying error and determining significance of results ... accessing information and communicating.

Assessment of primary school students is entirely school-based across the nation.

Secondary (High School) Biology Education

Biology does not exist as a separate discipline within junior high school curricula; however, traditional biological topics (such as photosynthesis and classification) are usually to be found in these courses. This paper does not attempt to provide an overview of the enor-

mous diversity of science programs at this level. The summary below, therefore, addresses only that biology which is taught in the final two years of high school.

The following content and process goals are common across Australia, although the emphasis varies from state to state. Some additional goals, unique to particular syllabi, are also identified.

Content

•History and philosophy of science (nature of scientific theories, verification of theories, limitations of scientific knowledge).
•Understanding of the social, cultural and technological contexts of biological knowledge (in particular, the influence of technology on quality of life and economic development via the improvement of health care, nutrition, and agricultural practices ... that technological developments may be the result of unforeseen consequences, rapid exploitation, or cultural change and, therefore, require prudent application).
•Diversity and classification.
•Cellular structure and function.
•Plant and animal structure, function and behavior.
•Principles of reproduction, inheritance, adaptation and evolution.
•Ecology and dynamics of living systems.
•Human impact on the environment.

All states have a general scientific literacy perspective that is usually expressed in terms of increased student understanding of the natural world, of their place within the natural world, and of their ability to make informed choices. "As citizens, it is also important that we have some understanding of the ways in which the natural world functions, how we interact with it, and some of the effects human actions can have. Being able to see ourselves too as a part of the whole living world can lead to a different view of ourselves and of our place in nature." (Western Australian Department of Education 1991, p. 61)

Scientific literacy also includes learning that will develop an understanding of the nature and limitations of the processes of science.

It is of note that two states have developed courses of study specifically in human biology (Tasmanian Schools Board 1990; Western Australian Department of Education 1992). These programs are very popular and continue to draw students away from traditional biology study in those states. The courses have the following themes: structure and function of the human body, the human life cycle, biological and cultural evolution, human ecology and contemporary social issues. The Western Australian course includes significant anthropological and population study components. This was done "to develop understanding of those factors influencing human population growth and demography and the impact of population growth, urbanization and industrialism on resource utilization and the environment." (Western Australian Department of Education 1992, p. 77)

Nor is biological content the exclusive domain of the science curriculum. Subject areas such as legal studies, health education, religious education and humanities address social aspects of biology, such as applied genetics, environmental release, euthanasia and reproductive technologies. The potential for cross-curriculum cooperation, though recognized, is rarely exploited.

Process

•Skills in experimental design, observation, record production, presentation of data, and communication of biological knowledge to

peers and the community beyond the school.
•Respect for evidence, rational interpretation of data, and intellectual honesty.
•Ability to exercise skeptical, creative and lateral thinking.
•Ability to integrate relevant knowledge from the other science subdisciplines.
•Development of personal skills — meaningful and selective retrieval of information from a variety of sources, including electronic databases; information analysis; cooperative group work; problem-solving skills; oral and written communication (one state formally recognizes biology communication as a legitimate component of the English literacy program).
•Ability to assess personal and social risks associated with biological knowledge and its application.
•Ability to critically interpret written biological communications, such as popular media reports and basic journal articles.

Although Australian biology education is now characterized by the existence of many syllabi and a diversity of texts, the influence of an Australianized *BSCS Green Version* (Morgan 1967), first introduced in the 1960s, can still be found in the widespread commitment to inquiry-based approaches in current syllabi. Research projects, whether laboratory or field-based, are also common to all states. Inquiry-based teaching strategies have become modified since the 1960s and are now used, to various extents, in conjunction with many other strategies.

Assessment in every state is a combination of school-based and external forms of varying proportions. Attempts to assess the processes of scientific investigation are in some states taking the form of internally examined and externally moderated (check) experimental reports. In one state, this involves the students presenting a report that details the rationale and procedure for an investigation of their own choice. A log book in which firsthand procedural notes and observations are recorded must be submitted as an assessment component (Victorian Curriculum and Assessment Board 1991).

Consensus & Re-Evaluation

Australian biology curricula have generally been developed by a process of consensus involving the state education authorities, university representative, and in most cases, science teacher professional associations. Course review is usually undertaken every three or five years and is the responsibility of the individual state education authorities.

Achievement of Goals

A. National Acceptance of Goals

Since the early 1960s, Australian biology education has moved from being essentially the study of plant and animal structure and function to one that encompasses philosophical and social (ethical and legal) aspects of applied biological knowledge. Possibly influenced by the environmental education movement, biology education now attempts to expand students' perspectives beyond the laboratory so as to include local, national and global issues.

This broader vision of biology education has been accepted by both the educational and wider communities. An economically developing Australia is widely perceived to be dependent upon the growth of new industries, including biological technologies. Biology education is now challenged to maintain a broader vision and to resist the economic imperative's view of what constitutes valuable biological knowledge and skills.

A current tension common to most states relates to the purposes of senior schooling. For biology education, this tension will occasion-

ally be expressed in terms of the perceived conflict between the needs of those students who do not intend to continue their education beyond the school years and the needs of those planning a course of tertiary study — "biology for all" versus "biology for future biologists." Each state claims that their syllabus meets the needs of both groups; however, the reality is usually determined by the values of the assessment system, a process usually directed towards tertiary selection.

B. Instructional Materials

Interpretation of each state's syllabus is largely a teacher responsibility, even in those states with a more prescriptive system. Textbook choice is the primary means whereby that interpretation is achieved. Despite the fact that Australian biology education is currently experiencing a rapid expansion in the number and style of texts, experimental manuals, thematic units, computer software and audiovisual resources, the translation of recent biological techniques into the classroom environment is limited by the absence of both a national coordinating body and a structure for the initiation and support of classroom experimental procedures. In spite of enlightened curriculum requirements in some states, school biology practical work will remain traditional until a system capable of advising teachers about the procedural and ethical aspects of more meaningful practical experiences, including the new technologies, is established.

C. Teacher Preparation

The majority of senior biology courses aim to address the scientific, social and technological issues related to the application of biological understanding; however, these areas of study are often poorly defined and frequently designated to the "optional" or "elective" sections of the syllabus statements. Genetic engineering, reproductive technologies, genetic counseling, and immunology related to the HIV viruses, for example, are mandatory components of only one state syllabus (Victorian Curriculum and Assessment Board 1991). The classroom reality, however, may not be consistent with the stated objectives. A most significant factor limiting the achievement of socially oriented biology education is undoubtedly the inadequate knowledge base of the teaching fraternity, many of whom were trained prior to the development of the new biological technologies.

One syllabus has attempted to integrate the study of traditional content and biological issues by requiring teachers to adopt a contextual approach (Victorian Curriculum and Assessment Board 1991). This approach requires the students to identify and explore issues of local, national or global significance. These issues thus provide a rational and meaningful context for studying the biological details of the course. This approach effectively reverses the traditional sequence of theory instruction followed, if time permits, by examples of what that theory means in the real world. "Science first" has become "reality first." Anecdotal reports suggest that a widespread and fundamental unease about changing one's teaching practices underlies an ignorance of and resistance to this pedagogical innovation within biology teaching.

The exponential growth in the volume of biological knowledge has prompted calls for the inclusion of content, skills and processes from the "new biology" in school biology courses. These calls mean that difficult selection and rejection decisions now have to be made. Current developments in the biological sciences can no longer be simply added on to the end of a unit of study. We cannot afford to regard these developments as somehow optional; however, the teaching community re-

quires considerable support for the process of reconceptualizing the domain of school biology education.

The problems facing Australian biology teachers are essentially ones of professional development. How can a teacher's knowledge base of contemporary biology be efficiently expanded? How can a teacher's understanding of the history and philosophy of biological science be likewise developed? How can we broaden the narrowly focused vision of a biology teacher trained 20 years ago (or even five years ago!) who is comfortable with teaching about the enzymes of the digestive system but is ignorant of, ambivalent towards, or desiring support for teaching about the ethics of germ cell therapy? How will students learn about the ethical considerations relating to the trialing of genetically modified organisms or of the economic and ethical aspects of patenting organisms?

In summary, it is the author's opinion that Australian school biology education could benefit from the inclusion of the following:
•An increased focus, at the classroom level, upon the social (legal, ethical and public policy) aspects of biological issues with an emphasis upon the development of skills of ethical analysis.

•Greater hands-on experience of the more recent biological techniques such as those used in tissue culturing, applied microbiology and basic molecular biology. The inclusion of such techniques should be guided by purposeful learning objectives that challenge the "anything of a practical nature must be good for the students" rationale.

•An increased emphasis, at the classroom level, on the nature of biological knowledge and its generation; i.e. the history and philosophy of biology — biology as a way of knowing.

•Greater emphasis on the importance of biological membranes in growth, cancer, immunity, biotechnology, etc.

Many factors have influenced the current deficits identified above, not the least of which is that of assessment priorities. A more socially and technologically oriented biology curriculum will be more widely implemented if it is accorded an appropriate status by the assessment system. The purpose and methods of assessment of STS skills and understanding are still the subject of academic and curriculum development debate and have yet to significantly impact upon those who implement curricula — the biology teachers. Until these issues are resolved, STS perspectives will remain as statements of good intention in syllabus statements nationwide.

With respect to the inclusion of practical exercises that acquaint the students with new biological techniques, at least two significant limiting factors have yet to be addressed:
•Lack of teacher expertise.
•Uncertainty within both the biology teacher community and the wider public as to the acceptability of the new technologies, especially their conduct within school laboratories.

Three key questions are foremost in teachers' minds:
•Are the techniques safe?
•Are we demystifying the technologies and/or authenticating their development and use?
•If students do perceive these activities as authentication of the new technologies, is this an appropriate attitude for school biology to be inculcating, given the wider community's uncertainty?

Syllabus revision in this country usually makes selection decisions by commencing with existing course content, rather than by starting afresh with a "clean slate" and asking what contemporary biology regards as essential. By moving a significant proportion of traditional plant and animal anatomy and physiology back into the junior and middle high school curriculum, room could be created in senior biology for inclusion of the above content.

A fundamental pedagogical change is now underway in Australian biology education. Teachers are required to become co-learners and to establish and maintain a balance between student needs, interests and prior knowledge on the one hand, and the knowledge and skills that the domain of academic biology deems to be important on the other. This change of role, together with advances in biological knowledge and the community's demands for schools to produce students capable of making a significant contribution to the future well-being of the nation, place unprecedented demands upon the biology teaching profession. Professional development will be a key factor influencing the future achievement of biology education's goals.

References

Australian Education Council. (1990). *K-12 science curriculum map.* Melbourne: Curriculum Corporation.

Morgan, D. (1967). *Biological science -- The web of life.* Canberra: Australian Academy of Science.

Tasmanian Schools Board. (1990). *Human biology.* Hobart.

Victorian Curriculum and Assessment Board. (1991). *Victorian certificate of education biology study design.* Melbourne: VCAB.

Western Australian Department of Education. (1991). *Biology (Year 12) -- E402.* Perth: Department of Education.

Western Australian Department of Education. (1992). *Human biology (Year 12) -- E406.* Perth: Department of Education.

Contributed Paper

Regional Report: A Russian View of Basic Biological Concepts

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Introduction

Basic biological concepts are being widely discussed in Russia, especially by university biology teachers and scientists specializing in biology. Primarily, these heated discussions focus on the problem of elaborating a unitary concept of education. This problem is linked to the currently ongoing radical changes in the societal attitude towards bioeducation. These attitudinal changes are necessary for overcoming the bio-illiteracy of all people on the Earth, regardless of an individual's country or social stratum.

As the participants of the discussion in Russia have pointed out, the elaboration of a novel bio-educational system focusing on a limited number of axioms is a necessity. The system of axioms should constitute the basis of all bio-curricula, especially curricula intended for nonbiologists. Of paramount importance is the central idea of using a limited array of axioms (basic concepts) in teaching biology.

Axioms

What are these axioms? How many are there? What message should they carry? There has been much country-wide discussion of these questions. Most agree with the statements made by Professor Boris Mednikov (Institute of Physio-Chemical Biology, Moscow State University) that the number of basic axioms should be kept to four.

It took more than two millennia to formulate the first axiom. Throughout this long period of time, man was concerned with the problem of how, for example, an egg, a homogeneous blob of white and yellow, can turn into a chicken with its head, wings and legs. What creates the system "chicken" with its intrinsic order? How do ordered systems characteristic of all the organisms on Earth come into being? This was a problem that could be solved only in the 20th century. Thus, Axiom #1 is as follows: *All living organisms represent a unity of the phenotype and the corresponding developmental program (genotype) that is handed down from generation to generation. The principal message that the program is inheritable is axiomatic.*

Axiom #2: *Hereditary molecules are synthesized using a matrix; the genes of the preceding generation are employed as the matrix.* This axiom (as well as the previous one) emphasizes that priority should be given not to the material substrate but to the matrix principle of its synthesis. Under the conditions characteristic of the Earth, proteins are poor matrices, whereas nucleic acids are much better. This, however, does not imply that the conditions are the same on all the other planets in the universe. Extraterrestrial genes may be composed of peculiar substances as yet unknown to us, but they also will have to follow the matrix principle of reproduction. The participants of the discussion in Russia are convinced that such a categorical statement is as valid as it is consistent with numerous facts.

Axiom #3 deals with the static of life. If the matrix biosynthesis machinery were allowed to operate perfectly well, none of us would

have ever been born. We would all still remain at the stage of protocells buoyant in the warm waters of pre-Cambrian seas. Thus, we need to consider the dynamics of life. In this context, it is essential to reveal laws governing the changes taking place in hereditary matrices. Thus, Axiom #3: *Genetic programs handed down from generation to generation are subject to casual, undirected changes.* These changes may become adaptive only by chance. This third axiom emphasizes the importance of errors; it also can be regarded as relevant to the principles of quantum mechanics.

Finally, there is Axiom #4: *When phenotypes take shape, the casual changes in genetic programs are amplified and exposed to environmental pressures leading to natural selection.* It is emphasized that selection deals not with the changed programs per se but with the resulting phenotypes, whose development involves amplification of all the "errors" made.

The participants of the discussion believe that these axioms are sufficient to explain all the phenomena in living nature, ranging from the origination of the first contractible fiber or the first enzyme molecule to the development of the thinking brain. Opponents usually respond to this with indignation by pointing out that biology is not reducible to physics and chemistry.

The proponents of the above axioms, as applied to bio-education, stress that the situations described by these axioms are unique to living nature, thus eliminating the reducibility problem. Although involving molecular level concepts, these axioms are applicable to more complex levels of biological organization. These axioms (in the opinion of their adherents) are of general importance, and they apply to all the levels and to all kinds of situations. Case-specific predictions can be deduced from them, as theorems are deduced from axioms.

Conclusion

Preliminary discussions in Russia conclude that (1) a new bioeducational approach is needed that is based on such concepts as language, program, matrix, copy, error, casuality, etc., and (2) the relationship between axioms and theorems must be clarified. This summarizes the new approach to biology education in Russia.

Contributed Paper

Standards for School-Level Biology Instruction in Germany

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Introduction

In 1973, the Association of German Biologists (Verband Deutscher Biologen) published a detailed syllabus for biology teaching at the primary and secondary school level (ages 6-18). The proposal was discussed, evaluated and eventually confirmed as a basis for biological education in West German schools in 1978 by the Schools Commission for the Association of German Biologists and representatives of all Bundeslander.

Discussion about necessary biological topics in teaching has not ceased since that time. An updated version of the syllabus was published in 1987, which incorporated significant movements of biology education in Germany and brought the syllabus up to date (Berck & Graf 1987). What follows is a review of the current discussion about biological topics and basic concepts of biology teaching in the Federal Republic of Germany.

A Rationale of Topic Selection in the '70s & '80s

From an analysis of man's current and likely future life situations (the Robinson curriculum approach 1969), the importance of a basic amount of biological knowledge and its interpretation in relation to the life of the individual and society becomes apparent. Furthermore, biology contributes greatly to the practice of formal skills through activities such as observation, abstraction, classification, interpretation, problem solving, spatial thought, critical application of methods, etc.

Biological knowledge is a necessary prerequisite for the pupil if he/she is to learn how to judge objectively, evaluate and find solutions to current problems involving food production, health, population and general standards of living.

The selection of topics for a biology syllabus can be justified on three different grounds: (1) for reasons pertaining to the society; (2) for reasons pertaining to the structure of the biological disciplines; and (3) for reasons pertaining to pupil's motivation. These three factors correspond to the usual demands for "social relevance," "subject relevance" and "pupil relevance." During the selection, care has to be taken to ensure that as many topics as possible can be justified in terms of all three criteria together but that each topic should reflect at least one of the criteria.

The topics and concepts listed in the following should not be seen as isolated pure areas of knowledge but always in connection with more general education goals. The topics merely delineate the content aspect of a teaching procedure which — seen as a whole — is much more complex. The basic concepts that are recommended for teaching are comprised of ordinary biological concepts on the concrete level, like "birds," "dog family" and "squirrel," as well as super-ordinate concepts on the abstract, formal level, like "adaptation," "structure," "function" and "regulation."

The topics are structured according to five age

groups:

Grades 1-4 (six- to nine-year-olds)

1. Observation of living animals and plants (especially mammals, birds and flowering plants).

2. Experimental problem solving, using suitable examples (conditions for germination and growth; phototropism; plant, animal and human respiration).

3. Signs of life of the human body intelligible to a child (for example, motion, nutrition, health, sexuality).

4. Biological dependence of man on plants and animals (foods and stimulants, medicinal herbs, fur).

5. Introduction to the maintenance, care and protection of plants and animals; construction of a biological collection.

6. Issues of ecology and environmental protection appropriate to this age group (death of fish, oil pollution, exhaust gases of motor cars, etc.).

Justifications

•Familiarity with local plants and animals and insight into the vulnerability of the organisms themselves as well as their mutual relationships will influence students as they confront environmental problems.

•The treatment of topics from human biology is important to insuring good health habits in children.

•Interdisciplinary general science instruction at the elementary school level should familiarize the student with his/her environment in a systematic way.

•The empirical method of acquiring information and becoming familiar with special biological objects provides the scientific foundation for subsequent biological instruction.

•Knowledge of the techniques of keeping plants and animals is a prerequisite for experimentation with living things.

•Students of this age are extremely interested in animals, and building up collections at home or at school fulfills the students' desire to collect, compare and classify.

•Pleasure in experimentation and observation requires a strong empirical form of instruction.

Grades 5 & 6 (10- & 11-year-olds)

1. Introduction of the cell concept, the microscopic dimension.

2. Experimentation, especially with plants, to explore the connection between structure and function (functions of leaf, stem, blossom, root).

3. Functional observation of the human body (examples from the physiology of metabolism, motion and the senses; protection against cold and heat; sight; taste; etc. as well as sex education, drug education and health education).

4. The concept of natural relationship, using selected examples (buttercup family, liliaceous plants, labiates, exercises in their identification, etc.). Domestication.

5. Adaptation of individual living things to various external conditions (air, water, time of

day or year). Interdependence of living things and their environment (for example, hibernation, adaptation to dryness, regulation in ecosystems, biological equilibrium).

6. Observation and explanation of animal behavior. The problem of understanding; relativity of anthropomorphisms (intelligence of chimpanzees, learning and instinctive behavior of squirrels, hamsters, gray-lag geese, etc.).

Justifications

•Society prescribes sex and health education at this stage in order to prepare the students for problems of life (puberty, drugs, diseases).

•Experimental treatment of plants is necessary for the comprehension of the basic significance of these organisms for the maintenance of the biosphere and, thus, of man's requirements for life.

•At this stage, an interest in questions relating to ecology and descent (animal and plant breeding) should be encouraged in order to develop a critical attitude toward biological decisions.

•A balanced self-conception of man is not possible without a well-founded knowledge about animal behavior patterns because only in view of this background will man's specificity emerge.

•The concept of the cell as the basic unit of living systems is useful for the treatment of most of the subsequent biological fields (for example, structure and function of organs, reproduction).

•The preparatory study of the concept or relationship first provides the possibility of introducing the qualitative comparison of complex structures ("comparative morphology," "comparative ethology").

•Popular anthropomorphisms can be removed at this stage, and with it, the interpretative way of thinking as a method in science can be fostered.

•At this stage, functional observation must be emphasized. Above all, the development of a desire to solve problems empirically is necessary.

•The discovery of new biological dimensions through use of the microscope is an exciting experience for students. It encourages their interest in the subject.

Grades 7 & 8 (12- & 13-year-olds)

1. Empirical investigation of ecological regularities on the basis of at least one selected ecosystem, such as:
a. Water system (population zones, water pollution).
b. Forest (strata with typical representatives, water balance, forest pests, forest exploitation, hunting, recreational function).
c. Agricultural area (with examples of important cultivated plants and weeds, mineral balance including fertilization, danger of erosion, productivity, pest control).

In connection with the above, the following concepts should be elaborated: biomass, food chain, food web, producer, consumer, decomposer, probiosis, symbiosis, parasitism, immigration and emigration.

2. Experimental treatment of photosynthesis and decomposition processes. Survey of the energy and matter cycles in the biosphere (oxygen, carbon, water, solar energy).

3. Concrete illustration of basic phenomena

of ethology (for example, innate trigger mechanisms, key stimuli, motivation, conflict behavior, idle actions, territorial behavior, aggression, social attraction and communication).

4. Deepening of the cell concept (cell division, chromosomes). Practice of simple microscopy technique.

5. Forms of reproduction: sexual, asexual (microscopic investigation of gametes, for example, in mosses, flowering plants, vertebrates; spore production; proliferation of off-shoots, buds, bulbs, etc.).

Justifications

•Deeper insight into complex ecological structures is necessary in order to strengthen the attitude of "care and caution" as far as biological objects and systems are concerned. Questions of the burdening of the environment with waste and chemicals must be dealt with and experienced by the students intensively at this stage (as far as possible by means of students' experiments).

•An understanding of the world's food problems requires some instruction in the phenomena of photosynthesis and the large energy and matter cycles.

•Ecosystems are examples of the integrative meshing of biological with physical, chemical and social/economic phenomena. It is made clear to the students that complex systems also require complex thinking and procedure and that quantitative statements are more difficult to achieve here than in simple technical systems.

•An encompassing comprehension of both human respiration — to be dealt with later on in grades 9 and 10 — and the ecological concepts to be developed at this stage require a knowledge of photosynthesis and matter cycles.

•Sexual and asexual reproduction, cell division and function of chromosomes are necessary for the teaching of sexuality, genetics and the evolution of man, which are to be dealt with in grades 9 and 10.

•Knowledge of the basic concepts of animal ethology is a prerequisite for a deep and critical understanding of human behavior, which is discussed in grades 9 and 10.

•Superordinate and complex biological topics with an integrating function (ecosystems, matter and energy cycles) meet the students' growing desire to organize their knowledge on a higher level.

Experimental investigations on topics of special social significance arouse considerable interest in students of this age group.

Biological topics in these grades and increased motor drive have an especially long-lasting motivational effect when they are elaborated by means of students' experiments.

Grades 9 & 10 (14- & 15-year-olds)

1. Functional anatomy of human organs and organ systems, including practice in methods of anatomy, physiology, possibly also cybernetics. Extensive treatment of health-related issues (nutrition, air, motion, critical development phases, infectious diseases and their therapy, including experiments in microbiology).

2. Reproduction and growth in man (procreation, embryonic development, birth, aging, death).

3. Comparative observation of human and animal behavior. Forms of sexual behavior and their social implications (individual and social, sexual behavior of man, family planning).

4. Fundamentals of heredity, including human genetics (empirical derivation of the Mendelian laws from family trees, chromosome theory, nature and nurture, variability, simple DNA model for the demonstration of the constancy or mutation of genetic material, plant and animal breeding, indications of eugenic problems).

5. Fundamentals of evolution: mechanisms (mutation, selection, recombination, isolation) in propaedeutic presentation. Survey of the natural taxonomy of the larger groups of the plant and animal kingdoms.

6. Man in the technological world: population explosion, world food problem, behavioral control of man (advertisement, mass media, drugs); biological aspects of workplace, accommodation, traffic, leisure time; medical technology; ecotechnology (protection of man's biosphere, control of ecologic equilibria — "spaceship Earth"); relations between science, technology, philosophy and religion.

Justifications

•For many students, general school education ends at this level. For this reason, human biology and all related questions (heredity, eugenics, nature and nurture, evolution, social behavior, biotechnology) should be dealt with in such a way that their basic contributions to an integral self-conception of the student are achieved.

•Treatment of the above topics is also a necessary foundation for proper decision making in later years.

•Sufficient knowledge of human organs, their functions and dysfunctions, is demanded by society for economic reasons (health, style of life, drug problems, public health, welfare, loss of working hours).

•By the end of this school level, all subdisciplines of biology should be treated to some degree in order for students to understand the nature of science and understand its most important findings.

•At this time of late puberty, students are interested in questions concerning "man" (man as an organism, man and nature, man and society, man and technology), since these questions concern them personally. A form of biology instruction that is centered on man therefore fulfills both the interests and needs of students.

Grades 11-13 (16- to 18-year-olds; upper secondary level)

At this level, biology instruction should consist of a number of extended courses, focusing either on scientific methods of research and description (Group I) or on particular topics of biology (Group II). Courses in Group I, the "fundamental" courses, are best placed at the beginning of this level (i.e. at Grade 11).

Group I. Interdisciplinary courses introducing new aspects or methods of biology (possibly in cooperation with teachers of mathematics, chemistry, physics, social sciences, etc.)

1. Statistics.
2. Philosophy of science.
3. Cybernetics, systems theory.
4. Biochemistry, biophysics.
5. Social sciences.
6. Cognitive philosophy (learning theories,

theories of concept formation).

Group II. Subject-specific biology courses

1. Ultrastructure, biochemistry and biophysics of the cell (biological membranes, diffusion, osmosis, membrane potential, cellular respiration, photosynthesis).

2. Developmental physiology (ontogenesis, determination, hormonal regulation, differentiation, dedifferentiation, immunization, etc.).

3. Genetics and evolution (molecular genetics, origin of life, evolution factors, population genetics, typogenesis, natural system of organisms, genetic and cultural evolution of man, future aspects).

4. Ecology (experimental investigation of ecosystems, mathematical analysis of ecological data, global aspects of human ecology, growth of population, environmental crisis, models of survival).

5. Comparative ethology (for example, man and animals as social beings, sexual behavior, man/machine problems), behavioral physiology (including neural physiology); aspects of communication and control (cybernetics); border questions of ethology and psychology.

Justifications

•Scientific orientation is an essential feature of instruction on this level. For a deeper understanding of scientific work and its impact on our present life, an exact and critical assessment of scientific methods is necessary. The aim must be to enable those students who will study at the university to avoid either worshipping or condemning science in an uncritical way.

•Selection of subject-specific topics from Group II should be done in such a way that, despite all specialization, there is integration with related and basic sciences. Students can chose one or two interdisciplinary or transdisciplinary courses from Group I that should be viewed as prerequisites for all specialized science courses. In the lower grades of general education, a nondisciplinary scientific instruction ("general science") is possible, and in the upper grades, there is the chance to offer "interdisciplinary" and also "transdisciplinary" (for example, cybernetics) instruction which fruitfully combines the basics from physics, chemistry, biology, mathematics and social studies.

•Offering a wide spectrum of topics in modern biology allows the student to concentrate on his/her own interests. The spectrum is set up in such a way that it fulfills the needs of a student to specialize in one scientific subject and to study in-depth in fields of his/her interest (for example, human evolution, human ethology, human genetics, human ecology). The student's freedom to choose should, however, be limited to those fields of biology in which biological methods can be studied and practiced in an adequate manner. Under no circumstances should it become possible to exclude biological instruction totally from the upper grades of school education because students would be missing an essential aspect of scientific thought which is so important in our technical world.

The second edition of the above outlined "Frame Syllabus for Biology Teaching at Schools," developed by the German Association of Biologists (Schaefer 1981), came to the same conclusions as to major topics and concepts of biology teaching as the earlier version; only minor adaptations took place (Berck & Graf 1987). It was noticed, however, that in

the 1980s, topics like health, environmental education, sociobiology, evolution, reproduction (sexuality), ecology, human biology, cytology, ethology and metabolism apparently increased in importance, though no special "rationale" was given.

It was just the new interests of society that brought about new thrusts in biology teaching. In the '80s, there was no new philosophy and no new conceptual approach for the selection of biological topics and concepts to be taught in schools.

Topic Selection in the '90s & Beyond

Continuous pressure on syllabus revision originates from a public desire to take societal issues and scientific progress into consideration by changing syllabus contents (with the aim being to make the curriculum "up-to-date" or "modern"). However, there is also now a simple need to reduce the amount of subject matter that is taught in classrooms. Exponentially growing biological knowledge, on the one hand, and time cuts on the other, lead necessarily to a limitation of contents down to a general core of biological knowledge and, thus, to the everlasting question of what this "core" might be. Syllabus commissions and curriculum workers rarely agree upon this. They often are happy if there is some overall pressure within the society towards some specific issues like biotechnology, genetic engineering, environmental protection, AIDS, etc., so that at least on these topics spontaneous consensus can be found.

In the following, a quite different approach to syllabus consensus will be made. It emerged out of empirical and theoretical studies on the concept of health (Schaefer & Hernandez 1985) and has proven its practicability for identifying a core of biology teaching in the city of Hamburg (1988, 1989).

Twelve Universal Principles of Life

During an international project on health education (Schaefer & Hernandez 1985), consensus was reached that biology teaching must reflect the fact that life in itself is multidimensional and polar. The analysis of this finding (Schaefer 1986, 1992; Wille 1992) shows that there are about 12 principles of life active in all organisms, as well as in the human mind.

1. Polarity (more precisely, active mastery of polarity; i.e. the integration of conflicting poles).
2. Conversion/fixation (change/constancy).
3. Order/disorder (negentropy/entropy).
4. Autonomy/dependence.
5. Controlled demarcation (opening/closing of borders).
6. Entanglement/disentanglement (the complexity of principle).
7. Variability/uniformity (diversity/monotony).
8. Adaptation/perseverance.
9. Valuation/devaluation (upgrading/degrading; the priority or "hierarchy" principle).
10. Movement /quiescence.
11. Interpretation/de-interpretation (sign and meaning: the "semantic" principle).
12. Storage/extinction of information (information copying; the "reproduction" principle).

Implementation

As the 12 principles of life in this short version sound rather abstract (and, in fact, they have been purposely formulated like this in order to make them applicable in different life sciences), teachers often argue they might not be understandable to the students. They hesitate to teach them in explicit form and prefer implicit presentation by means of concrete examples. It is recommended, therefore, that the following sequence be followed in presenting the principles within the context of biological science:

•First, there should be the discovery of a

specific principle of life through skillfully selected examples (implicit phase).

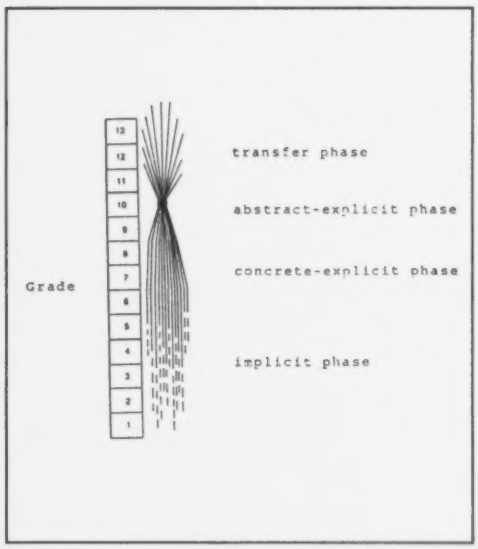
•A principle should then be explicitly elaborated and formulated (concrete-explicit phase).

•All 12 principles should be treated in this way.

•Later on (at the end of lower secondary level), the 12 principles should be formalized more precisely, and their general validity demonstrated, by means of further biological examples (abstract-explicit phase).

•Finally (earliest in Grade 10; better in the upper secondary level), the principles can be applied to all organizational levels of organic life and also to nonbiological areas (e.g. the human mind, social structures, economic systems) with the critical question being whether these systems really are "living" (transfer phase).

For illustration, the sequence of steps is diagrammatically represented in the following figure:



Selection of Examples

It is up to each syllabus commission to find adequate examples from biology for the principles and to integrate them into the syllabus. During this process, the commission will often not primarily be guided by the principles approach but will begin its work with other criteria. Thus, for example, the new syllabi of Hamburg for the lower secondary level are characterized by a human-centered approach, that for Grade 11 (pre-phase of the upper secondary level) by the thematic criteria "biotechnology" and "cytology," and that for Grades 12 and 13 by the usual subdisciplines of biology (physiology, genetics, ethology, ecology, theory of evolution). The addition of the principles of life to these thematic thrusts ended up ... with the creation of a "mixed type" of syllabus.

Selection of Themes According to the Principles of Life

In order to better explain this approach, a spectrum of biological themes is offered below for each of the 12 principles of life:

Polarity

Study of the polarity of all following principles: sexuality, DNA double helix, redox processes, symmetries, health/disease.

Conversion/fixation

•Study of the shifting or maintenance of present compromise points in all principles.
•Metabolism. (Conversion/fixation of biochemical substances. Examples: active fats/depot fats, monosaccharids/polysaccharids.)
•Metamorphoses. (Animals — larval stages.

Figure 1. Recommended sequence of teaching steps for introducing the 12 principles of life into general science and biology teaching at primary and secondary schools.

Plants — change of function and shape in roots, shoots, leaves.)

Order/Disorder
•The natural system of organisms and the "accidents."
•Morphological structures of plants and animals and their aberrations.
•The genetic reaction norm as "free play of chaos within the frame of order."
•Identical reduplication/mutation.
•Mendelian "laws" or "rules."
•Deterministic/stochastic laws.
•Evolution as the development of order from chaos.
•Order and disorder in ecosystems (e.g. regulation cycles/disturbing factors).
•Order and disorder in populations (social structures and their disturbances).

Autonomy/Dependence
•Poikilothermous/homeothermous animals.
•Homeostasis by regulation cycles (human body: sugar level, water economy, carbon dioxide content in blood, body temperature, etc.).
•Autonomous growth by reinforcement (autocatalysis, exponential growth, population pressure, etc.).
•Evolution as the increase of self-determination in organisms.
•Ecological dependences (ecological niche, symbiosis, probiosis, parasitism).
•External control by stimuli (tropisms, taxies, stimulus/reaction mechanisms).
•External control by matter and energy fluxes (photosynthesis, nutrition, respiration).

Opening/Closing of Borders
•Biomembranes (endoplasmic reticulum, cell organelles, plasmalemma, permeability, semipermeability).
•Epidermis of plants, stomata.
•Cork, lenticels, bark.
•Pulsing vacuole in protozoa.
•Vertebrate skin with pores, scales, hair, feathers.
•Openings of the body, sphincters.
•Territorial borders of animals or populations.
•Encystments (e.g. protozoa, bacteria, spores, pollen grains).

Entanglement/Disentanglement
•Metabolic pathways and their multiple connections (e.g. via glucose, ATP, fatty acids).
•Social networks, outsiders, isolation.
•Vegetative reproduction through buds and stolons.
•Mycelium of fungi, spores, slime molds.
•Food web/food chains in ecosystems.

Variability/Uniformity
•Twin research: equality/inequality of one-egged and two-egged twins.
•Individuality of man/uniformity in a mass society.
•Equality of cells in a tissue.
•Morphological variability of the leaves of a tree.
•Differentiation/dedifferentiation (embryolization) of tissues.
•Genetic variability: subspecies, varieties, races (breeds of dogs, pigeons, roses, dahlias).
•Measuring of beans' length: random distribution (Gauß curve).
•Measuring of comparable body dimensions of man (fingers, limbs, ears, eyes, etc.).
•Mathematics of variability: statistics.

Adaptation/Persistence
•Modifications (e.g. sun leaves/shade leaves, diurnal rhythms, tropisms).
•Eye: dark-light adaptation. Close distant accommodation.
•Immunological systems (specific antibody production against any kind of antigene).
•Conductance of body.

•Social adaptation/non-adaptation.
•"Adaptedness" of species by natural selection/genetic rigidity of individuals.

Valuation/Devaluation
•Selective ion uptake through the root hairs of higher plants.
•Social ranking in animals and humans.
•Priorities of food.
•Sexual mating.
•Vegetation levels in a forest.
•Food pyramids in ecosystems.

Movement/Quiescence
•Active carrier molecules.
•Cytoplasmic flow.
•Turgor movements in plants.
•Free stimulus movements (taxis).
•Myofibrils, muscles.
•Arresting of limbs.
•Active dormancy (in plants: nyctinastic movements).
•Active hibernation, forms of hibernation (e.g. fall of leaves).

Interpretation/De-interpretation
•Genetic translation RNA — protein in ribosomes.
•Flower signals (color, form, smell).
•Animal and human signals.
•Inborn trigger mechanisms.
•Acquired trigger mechanisms and their removal.
•Stimulus movements of plants (tropisms, etc.).
•Immunological reactions (recognition of antigenes).
•Hormonal control.
•Codification/decodification.

Information Storage/Extinction
•Genetic replication DNA.
•Transcription DNA — RNA, replication errors, mutations.
•Mendelian rules.
•Mitosis, meiosis, recombination of genomes.
•Learning, training, instinctive formation, conditioned reflexes and their decline, forgetting.
•Immunization (antibody production) and its deterioration.
•The three kinds of "memory" in higher organisms: genetic, neuronal and immunological.

Conclusion
The examples and themes listed above show that, by using the 12 principles of life as selection criteria, themes can be defined that cover all essential parts of biology and represent this subject in school teaching very well. In contrast to most of the conventional syllabi, which are structured in a more encyclopedic way trying to represent the whole of biology, here the attempt is made to use selected themes as "advance organizers" (Ausubel 1960) which are suitable crystallization points of knowledge. They may not be so important by themselves but more as "vehicles of basic biological understanding." It is the understanding of life that matters.

If we are to make a choice about the "most important" concepts for biology teaching, those concepts deserve the highest rank that can serve (a) as advance organizers of biological knowledge in general and (b) as basic concepts for the understanding of life in all its manifestations. The 12 principles of life described above, which entail 23 fundamental concepts, like polarity, conversion, border, autonomy, etc., do just this. They form an appropriate rationale for topic selection in the '90s and beyond.

References
Ausubel, D.P. (1960). The use of advance organizers in the learning and retention of

meaningful verbal material. *Journal of Educational Psychology, 51*, 267-272.

Berck, K.H. & Graf, D. (Eds.). (1987). *Rahmenplan des verbandes Deutscher biologen f'ür das schulfach biologie.* (From syllabus of the Association of German Biologists for Biology in Schools). Publ. VDBiol no. 7, Bremen.

Kallen, F. (Ed.). (1978). Ad hoc conference on society and the study of science, mathematics and technology. Strasbourg: Standing Conference of European Ministers of Education.

Robinson, S.B. (1969). *Bildungsreform als reform des curriculum.* (Educational reform as a reform of the curriculum). Neuwied: Luchterhand.

Schaefer, G. (1981). Frame syllabus for biology teaching at schools. *European Journal of Science Education, 3*(1), 47-61.

Schaefer, G. & Hernandez, D. (Eds.). (1985). *Health education through biology teaching.* IUBS-CBE Monograph. Quezon City: University of the Philippines, ISMED.

Schaefer, G. (Ed.). (1986). *Modern accents in biology teaching.* Special newsletter of IUBS-CBE, in cooperation with UNESCO. Hamburg: Commission for Biological Education.

Schaefer, G. (1992). Post-16 training and education in Europe. *Biologist* (in print).

Willie, J. (1992). *Untersuchungen zum lebensbegriff und möglichkeiten der anwendung, insbesondere im biologieunterricht.* (Studies on the concept of life and possibilities of application, in particular to biology teaching). Dissertation Hamburg.

Contributed Paper

Biology Education in the Netherlands

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The National Biology Curriculum: Goals & Implementation

Assessments of biological knowledge and skills in the Netherlands take place during three successive stages of the school life of a pupil. In primary education, biological subject matter is integrated in the subject area of natural science, which includes both biology and health instruction.

The second assessment level, which is not in operation yet, will take place at the age of 15 after an elaborate transition phase of three years, common to all Dutch students, no matter what the student's level of ability. This new structure of lower secondary education is called "basisvorming" and delays the streaming of pupils by ability. Biology is a compulsory subject for all pupils in the "basisvorming."

The final assessment is not yet regulated but will presumably take place via a national test in combination with school reports at age 18.

The ability streams in education remain in the same manner depicted in Figure 1, but they will start at a later age level. At the end of the four streams (pre-university, senior general secondary, junior general secondary, and junior secondary vocational education), national biology examinations and internal biology examinations of the school will take place for those students who have chosen biology as a subject.

For all three levels of assessment and for all different streams in higher secondary education, new biology goals are being formulated and accepted by the government. The implementation of these new curriculum standards is now in progress for all levels. The first national examinations for lower secondary education ("basisvorming") are scheduled in 1993. Junior general secondary education (MAVO) and junior secondary vocational education (LBO) are already using new national biology examinations. For pre-university education (VWO) and senior general secondary education (HAVO), new national biology examinations are planned in 1994 and 1995 respectively.

Specification of the National Biology Goals

A. Goals for primary education (ages 4-12 years)

Primary education promotes the development of the emotions, the intellect and creativity of children as well as their acquisition of essential knowledge and social, cultural and physical skills. The underlying assumption is that there should be a steady, uninterrupted process of development. Education should take due account of the fact that students are growing up in a multicultural society.

With regard to the content of biology education, two subject areas contain relevant goals. One subject area is nature, which includes the biology of plants and animals and the environment. Students are asked to describe and observe the surroundings of the school and are encouraged to respect, enjoy and develop a

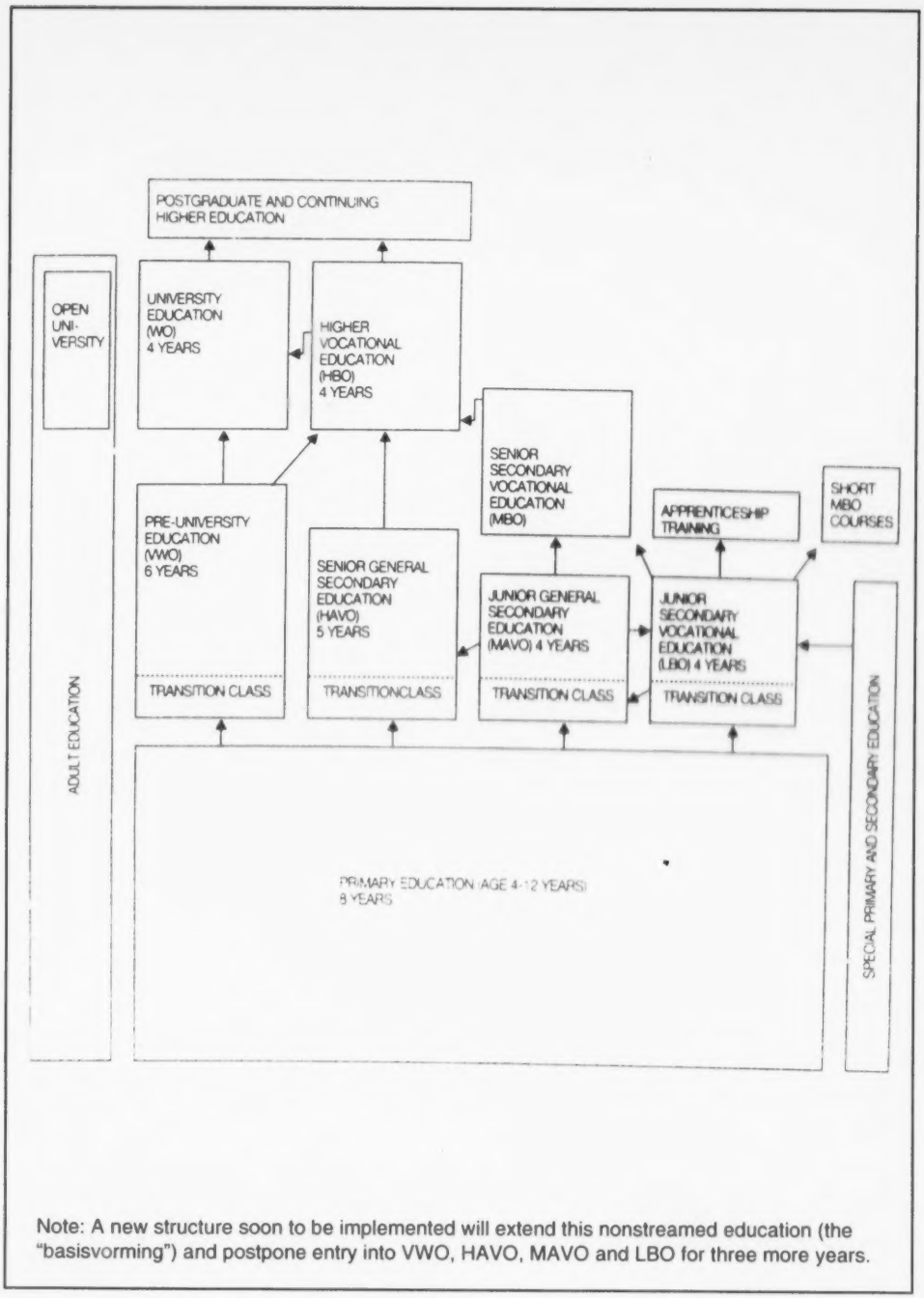
POSTGRADUATE AND CONTINUING HIGHER EDUCATION
OPEN UNI-VERSITY
UNIVERSITY EDUCATION (WO) 4 YEARS
HIGHER VOCATIONAL EDUCATION (HBO) 4 YEARS
SENIOR SECONDARY VOCATIONAL EDUCATION (MBO)
APPRENTICESHIP TRAINING
SHORT MBO COURSES
PRE-UNIVERSITY EDUCATION (VWO) 6 YEARS
SENIOR GENERAL SECONDARY EDUCATION (HAVO) 5 YEARS
JUNIOR GENERAL SECONDARY EDUCATION (MAVO) 4 YEARS
JUNIOR SECONDARY VOCATIONAL EDUCATION (LBO) 4 YEARS
TRANSITION CLASS
TRANSITION CLASS
TRANSITION CLASS
TRANSITION CLASS
ADULT EDUCATION
PRIMARY EDUCATION (AGE 4-12 YEARS) 8 YEARS
SPECIAL PRIMARY AND SECONDARY EDUCATION
Note: A new structure soon to be implemented will extend this nonstreamed education (the "basisvorming") and postpone entry into VWO, HAVO, MAVO and LBO for three more years.

Figure 1. Diagram of the Dutch education system.

responsible attitude towards nature and the environment. The second subject area is health and health care, including skills for hygiene and other preventive behavior (e.g. food choices). The human body and its functions are studied, too.

On a national level, the biology goals for primary education provide schools with choices as to what and how to teach. School work plans that are designed every other year clarify matters such as the teaching and developmental objectives of the school, the choice of subject matter, the organization of the school, and the way in which pupils' progress is assessed. The Primary Education Act gives guidelines for the planning of the curriculum and for methods of instruction.

The law does not dictate which teaching aids and measures should be used in the schools. Schools make their own decisions in this respect, and the items chosen are the property of the school. The production, distribution and sale of teaching aids are commercial activities in the Netherlands.

B. Goals for Lower Secondary Education

The goals for the biology program in the "basisvorming" are organized in three interrelated subject areas:

1. Man
- •Metabolism.
- •Movement.
- •Growth.
- •Propagation and sexuality.
- •Perception.
- •Behavior.
- •Man and animal.

2. Plants and animals
- •Diversity.
- •Adaptation.
- •Cycles.
- •Interdependence.

3. Plants, animals, man and environment
- •Food production.
- •Agricultural methods.
- •Environmental pollution.

Besides these knowledge areas, skills are prescribed for use by students in conjunction with the knowledge elements. The associated skills are:
- •Observation.
- •Use of information.
- •Use of computers.
- •Learning to choose (decision making).

The number of lessons to be spent on this biology program is advised by the government to be 160.

The schools are free to develop a biology curriculum that meets the specified goals; this leads to a great variety of curricula within the country. For instance, the goal of human propagation and prevention of propagation can be combined with the goal of human behavior and its biological, psychological, sociocultural and other roots. Both can be explored using the skill of "use of information," thereby leading to class activities like small group discussions or the writing of reports.

Both national and school-based examinations will contribute to the final assessment of "basisvorming" knowledge. Skill tests are still under development at teacher training institutes in the Netherlands.

C. Goals for Higher Secondary Education

There are two main branches of higher secondary education. The first consists of general secondary education and pre-university education. The second consists of junior and senior vocational education.

Biology as a subject is an option out of six (MAVO), seven (HAVO) or more (VWO) subjects that candidates can take for examination. The goals for all those examination streams are formulated and in the process of being implemented.

C1. Junior Secondary Level

The biology goals for junior vocational (LBO) and junior general secondary education (MAVO) are an elaboration of the same goals as formulated for the "basisvorming." Stressed are name-giving and recognition of perceivable phenomena. Cellular phenomena and biochemical processes are not dealt with in detail. The applications of biological knowledge to situations of daily life like health, food, agriculture and environment are separate goals. Skills are defined as part of the goals in the same way as in the "basisvorming."

For the biology program in MAVO and LBO, a total of 120-160 lessons are available. Schools can still choose how to distribute lessons among the school subjects.

C2. Senior General Secondary Level

The biology examination goals for senior general secondary education (HAVO) are formulated in a societal context: health for people, care for the environment, and human nutrition. The main goal for this program is the coupling of biological knowledge to the functioning of students in society, both now and in the future.

The biological content of the program includes the following (with some societal content issues indicated between brackets):

1. Course of life
- •Cells (DNA, biotechnology).
- •Plants (agriculture, source of medicines).
- •Animals, man (sexuality, anti-conception, AIDS).

2. Diversity
- •Systematics.
- •Origin of diversity in populations (prenatal diagnosis).
- •Genetics and evolution (*in vitro* fertilization).

3. Ecology
- •Metabolism and cycles (acid rain and methods of conservation).
- •Ecosystems (world food problems).
- •Stability and change in ecosystems (entrophy, monocultures, plagues).

4. Behavior
- •Behavioral systems (eating, sexual behavior).
- •Learning (role of genetics).
- •Social behavior (man and woman, aggression).

5. Human body
- •Cellular processes and body functioning.
- •Digestion, respiration, transport and excretion (health aspects).
- •Nervous systems, sensory organs, hormones and neuro-hormonal glands (alcohol effects).
- •Skeleton, muscles and skin (spots).

The examination is neither pedagogical or didactic and is determined by the schools. There are both a national biology HAVO examination and a school examination. In the latter one, prescribed skills are tested in conjunction with practical work. Both examination results are weighted equally and contribute to the final result for the student. In this program, 320 lessons are available for the biology curriculum. In addition, extra time is available for excursions, visits to industry, field work, research outside of school, etc.

C3. Pre-University Level

The goals of the examination program of the pre-university education (VWO) level are for-

mulated in the context of recent scientific biological thinking. Life is studied at various levels of organization — ecosystems, organisms and cells. Processes and structures on these levels are studied by different research methods. Conceptual development on a more theoretical level is stressed, both at the knowledge and at the skill levels, and is explicitly related to scientific thinking. The knowledge elements in the examination program are organized as follows:

1. Structures
•Ecosystems (climates, diversity, relations).
•Organisms (tissues, organs).
•Cells (EM pictures, organelles).

2. Life cycle
•Organisms (growth and development, embryogenesis).
•Cells (DNA, chromosomes, membranes, virus).

3. Metabolism
•Ecosystems (energy flow or cycles of matter, productivity).
•Organisms (photosynthesis, transport, digestion).
•Cells (dissimilation and assimilation, protein synthesis, enzymes).

4. Stability and change in organisms
•Ecosystems (behavior, stress).
•Organisms (regulation, sensory physiology, muscles).
•Cells (neuron functioning, muscle contraction).

5. Stability and change in ecosystems
•Ecosystems (population dynamics, agriculture, gene pools).
•Organisms and cells (genetics, genes, cloning, recombinant DNA).

Again, the pedagogical-didactical structures into which these elements are embedded, together with skill goals, are formulated in the schools. Examinations take place in the manner as described for the HAVO level. For the pre-university level, 320-400 lessons are available to the schools for use in their curricula.

D. Skills in Higher Secondary Education

Skills and knowledge acquisition form an integral part of the examination goals in biology. Schools are free to specify the content and the nature of student activities and to make connections to the practical work and knowledge goals. The general heading for all the skills in the biology examination can be formulated as "acquiring and digesting information" and can be summarized in Figure 2.

Updating of Goals in Biology

In the Netherlands, there is no systematic manner in which reform takes place. The ongoing reform now is mainly initiated and supported by biology teaching organizations, teacher training institutes, and some school inspectors, under supervision of the Dutch government. Ideas for evaluation of the new curriculum are being discussed by the government. The expectations are that a connection will be made with tertiary education systems to link their expectations of pupil abilities with new VWO skills and specific subject knowledge.

At the level of the schools, biology teachers are busy implementing the new curriculum, and an evaluation of the new curriculum will take place in the near future.

Implementation Experiences in Secondary Education

A. Teachers seem to accept the new curriculum, judging from the personal contacts between teachers and teacher trainers in inservice courses on the new curriculum. The govern-

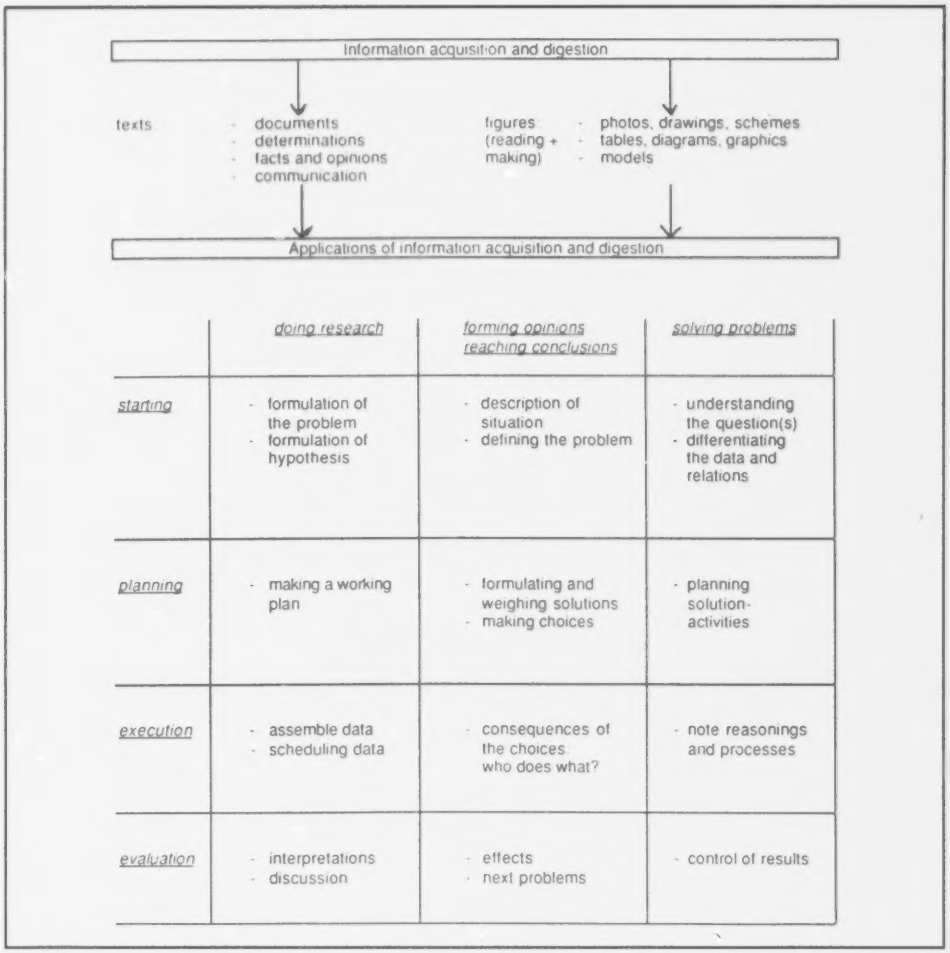

Figure 2. Skills for biology.

ment supports those courses in which sample lesson plans are developed and tested.

Pupils of the three experimental schools in Holland that are already practicing the new goals react enthusiastically. Teacher organizations and the government are constantly discussing the number of lessons available per level for biology teaching. Teacher organizations have pleaded with success for more biology lessons in "basisvorming" to ensure qualitatively good biology instruction.

B. The availability of appropriate instructional materials in the form of schoolbooks is regulated by five or six commercial educational publishers. They develop and offer in a free market biology schoolbooks that are appropriate for the different school levels. Besides books, sample materials are offered to

schools and teachers under sponsorship of the government or other organizations, like health organizations.

Schools themselves are normally equipped with laboratory facilities and instruments for use in biology lessons. In most schools (but not in all, especially in the junior secondary level), a technical educational assistant is present to assist teachers with practical work in biology.

C. Teacher training for the new biology curricula is underway in the form of inservice training in the Netherlands. Teacher training institutes offer courses, many of which are coordinated nationally.

In general, the role of the teacher has changed in the new curricula from a talker to an observer and stimulator of students. Teachers now consider each student's learning processes. This approach is more dominant in secondary education. In primary education, such changes in methods are much less evident.

D. Schools and society must provide sufficient opportunities to learn. In the schools, between 160-500 lessons are available, and these sometimes restrict the time available for teacher-pupil contact. The opportunity is also given in schools for excursions, visits, research activities, and field work by the students. Libraries, science museums, zoos, botanical gardens and national parks offer many opportunities for out-of-school studies. Some local authorities support natural history councils that offer special biological activities for mainly primary levels but sometimes secondary education students and schools.

E. Schools have become more autonomous than ever in the Netherlands. Control of the school budget has been relocated from the government to the schools themselves (formation budget system). Schools are now responsible for the expenditures for personnel and materials without government regulations.

Contributed Paper

Biological Education in the United Kingdom

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Context

While much of what is described in this paper applies generally in the United Kingdom (UK), its focus is on England and Wales. The education systems of Scotland and Northern Ireland have differences which here we will acknowledge but not describe.

After a history in which the curriculum was perceived as the province of the individual school and, indeed particularly in secondary education, the responsibility of the individual teacher, the situation in the UK has changed dramatically. Since the passing of the Education Reform Act of 1988, an obligatory, highly structured national curriculum for ages 5-16 has been installed.

The content of the curriculum is defined by:
•Attainment Targets .·. subdivisions of the content of a subject.
•Levels of Attainment ... descriptions of understanding and capabilities of increasing difficulty for each Attainment Target.
•Key Stages ... periods of study after which students are assessed by national, standardized tests, called SATS (Standard Assessment Tasks).

Although the number of "Attainment Targets" varies among subjects, for all targets there are 10 "Levels of Attainment." Each "Key Stage" successively covers a wider range of Levels of Attainment. For example, at Key Stage 1, Levels of Attainment 1-3 must be attained; at KS2, Levels 2-5 must be mastered; at KS3, Levels 3-7 must be mastered; and at KS4, Levels 4-10 are stressed.

The curriculum as a whole consists of CORE subjects — English, mathematics and science — and FOUNDATION subjects — history, geography, technology, music, art and physical education, with modern foreign language at Key Stages 3 and 4. Generally, subjects cover approximately 10% of a weekly timetable, although this is not prescribed, and indeed, science frequently covers 20%. The opportunity for choice of subject or of subject matter is extremely limited.

Biology in the National Curriculum

Biology is included within the subject of "science." Originally defined by 17 Attainment Targets, science is now covered, through amalgamation of these, by the following four (4) Attainment Targets:
- AT1 (Scientific investigation).
- AT2 (Life and living processes).
- AT3 (Materials and their properties).
- AT4 (Physical processes).

In effect, AT2 is biology, although AT1 integrates with it. The descriptions of these Attainment Targets are as follows:

AT1 (Scientific Investigation)

Students should develop intellectual and practical skills that allow them to explore the world of science and develop understanding of scientific phenomena, the nature of theories, and procedures of scientific exploration and investigation. This should take place through activities that require a progressively more systematic and quantified approach which develops and draws on an increasing knowledge and understanding of science. The activities

should encourage the ability to plan and carry out investigations in which students:
•Ask questions, predict and hypothesize.
•Observe, measure and manipulate variables.
•Interpret their results and evaluate scientific evidence.

AT2 (Life and Living Processes)
Students should develop knowledge and understanding of:
•Life processes and the organization of living things.
•The diversity and classification of living things, including the causes of variation and the basic mechanisms of inheritance and evolution.
•The factors affecting the size of populations and human influences within ecosystems.
•Energy flows and cycles of matter within ecosystems.

The general certificate in secondary education (GCSE) is the school-leaving examination in England and Wales, taken at the age of 16. Eventually, the assessment of Key Stage 4 and the GCSE will be merged. However, currently biology can be taken as a single subject for the GCSE, and it will be interesting to see if that remains. Presumably, it would take the form of AT2 — but with an expansion of detail.

General Certificate of Education (GCE) — Advanced Level
This biology course for students of 16-18 years serves partly as a university entrance examination but also as a subject for general education and as a supporting subject for entrance to a variety of further education courses and non-graduate occupations. A minority of those taking A-level biology will take a biological science or a related subject — e.g. medicine — at university.

Advanced Level examinations are conducted by eight examination boards, and schools can freely choose which they use — although normally this is the board geographically nearest. There is some variation in the syllabi for biology.

Students will normally take three Advanced Level subjects, occupying about 70% of the school timetable and all their homework time. Because of this high level of specialization, the standard of Advanced Level courses compares with first or second year university courses in some countries.

Biology in UK Schools — Conclusions & Queries
The trend in recent years in the UK is that of defining curriculum goals and objectives ever more finely. However, there are signs that a combination of the complexity and inflexibility of the National Curriculum model and the effects of the load of implementation on teachers is producing a reaction against it. Already this has happened in, for example, the reduction in the number of Attainment Targets in science and the removal of the more open-ended, practical items in the assessment tests.

For biology, the curriculum covers a broad range of understanding of knowledge and processes. Scientific thinking and methods are covered in considerable breadth and developing depth, and there are opportunities, although of a lesser extent, to study social issues related to biology. For the latter, there is little indication of developing appropriate thinking skills — ethics, for example, is not mentioned. What evidence there is suggests that the topics included for biology are ones that biology teachers would want. Disagreement is more with the overall structure of the system. There is concern about the potential limiting influence of the assessment tests with their emphasis on knowledge, per se.

Contributed Paper

Content, Educational Process, & Basic Concepts & Skills in Canadian Precollege Biology Curricula

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Prologue: What Are the Principles (Fundamental Concepts) of Biology?

The following are the principles of biology that I have tried to teach to first-year biology students at the University of British Columbia during the last 25 years.

1. In spite of great chemical complexity, living organisms are fundamentally uniform.

2. Survival of life on Earth depends on great diversity of life forms.

3. All living organisms arise from their predecessors by transfer of information from one generation to the next.

4. Living systems can only function when their compartmentalization is integrated.

5. Organisms in one generation are fundamentally similar to their parents.

6. Fundamental interactions within an individual organism are analogous to those within cells and those within ecosystems.

7. The processes of life are generally limited to events that are fundamentally stable within narrow limits of physical and chemical variables.

It is clear to me that, while no provincial curriculum articulates such fundamental ideas as part of the mandate for the education of young people in biology, the information covered during 12 or 13 years of school experience could be applied very effectively to entrench these principles into the minds of most students. The issue in Canada is, therefore, not what principles are taught but why none are taught.

In spite of the lack of a national curriculum and the absence of clearly-stated principles of biology in the foundation of the provincial curricula, there is remarkable homogeneity in the experiences of students across the country. Most students who complete provincial precollege biology curricula appear to have a basic grasp of biological concepts that, with appropriate reinforcement, allow good progress in tertiary education.

Students know some biological language, and better students have covered material and ideas in cell biology, human physiology, organismal diversity, genetics, and environmental biology to levels approaching or exceeding first-year university courses. On the other hand, less gifted students, who have either been encouraged to cram for the test or have fallen back on the security that most examinations are multiple choice, seem to treat first-year university as further opportunity to cram "facts" and frequently perform well below their predicted levels because they continue to work without grasping the underlying and unifying concepts.

The continuity of courses from year to year and the spiral, successive development of knowledge, skills and level of difficulty are particular features of the curriculum. The intentions here are laudable, but it has to be acknowledged that much of the structure up to the age of 16 is untested, and a close examination of the meaning of statements such as those of the Levels of Attainment raises serious questions of interpretation. Furthermore, the validity of the concept of stages of learning at 2-3 year intervals (the Key Stages of the National Curriculum plus A-Level GCE) is open to criticisms similar to those leveled against the use of Piagetian stages — probably more so because the Key Stages are more finely defined. The overlap of Levels of Attainment through the Key Stages further raises issues of validity and, more forcibly, those of implementation. Teachers are certainly voicing their concerns on the matter.

Two national bodies have been established to develop, evaluate and update the curriculum, the National Curriculum Council and the Secondary Examinations and Assessment Council. They both have responsibility for research. Judging by the volume of publications coming from these bodies, there is no doubt about their high level of activity. Currently this is focused firmly on the 10-year program for introducing the National Curriculum.

How adaptable the new system will be has still to be demonstrated. So far, change has been in relation to realigning content and structures already present. Given the magnitude of the task of implementing the system, it appears unlikely that any major adaptation will occur in the '90s. In balance, the system appears to be one favoring conservation rather than adaptation.

At this stage, the major influences on the implementation of the National Curriculum are the publications of the National Curriculum Council aided by inservice training, much of it being in-house and linked to school-based curriculum development. The National Curriculum is also a major feature of initial teacher education courses. Textbook publishers are producing books conforming very closely to the new regulations. The difference between the books is more a matter of style than content. Laboratory and other resources for National Curriculum biology are similar to those of previous courses.

Certainly, no extra funds have been provided to supplement this curriculum. Indeed, except for some provision for inservice courses, there has been little extra financial support for schools implementing the National Curriculum. If previous research on curriculum implementation is anything to go on, then the future will see textbooks and, particularly, the assessment tests becoming the major influences on teaching and learning.

The future of the Advanced Level GCE system is currently a matter of strong political and professional discussion. The government sees it as the "gold standard" setting high targets for schools to foster the education of high ability students. An alternative view considers the ages of 16-18 as too young for specialization and emphasizes the need for a broader curriculum as a precursor for a wide range of university and other courses. As most other European countries have broad-based curricula at the same stage of a student's career, it is also argued that the UK should do likewise in order to facilitate student mobility among European Community states.

The Process of Science

The stated science curriculum intentions throughout Canada are that science is a process, ideally involving formulation and testing of hypotheses, that allows us to satisfy our curiosity. It is encouraging and noteworthy that none of the curriculum documents states that science is the receipt, storage, retention and regurgitation of "facts." It is thus surprising that statements of the principles of biology are absent from Canadian school curriculum documents.

Biology Concepts at the Elementary Level

"The foundation of effective science curriculum and instruction should reflect the nature of science, the needs of society, and the nature of the learner." [British Columbia Ministry of Education. (1983). *Elementary Science Guide, Grades 1-7*, p. 6, Victoria, BC]. The four goal statements that follow this statement of rationale are:

"That the British Columbia (BC) Elementary School Science Program should develop in students:

A. Appropriate science attitudes.
B. The process and skills of science.
C. Scientific knowledge.
D. Creative, rational and critical thinking."

The intent is that content will be a balance between biology, earth/space science and physical sciences and will provide students with opportunities to do "hands-on," textbook-based and investigative studies. The emphasis is on the processes of science.

Canadian elementary students are probably no different from their peers around the world. They are variously fascinated and repelled by living organisms. Urban children watch lots of television, and some are actively exposed to high-caliber natural history shows. Rural children also have TV, but they have seen wild animals, watched births of domesticated animals, been a part of the hunt, or simply lived in a world that is much closer to nature than that of their urban peers. They are surrounded by frequently more obvious and diverse expressions of the seasons than are their urban counterparts. In spite of these realities, none of the curriculum materials recognized or allowed for this real variable.

Most Canadian early school biology experiences are directed to asking, "What is living?," and to encouraging students to "show and tell" and to ask and answer questions. Subject matter includes differences between plants and animals, diversity of living forms, first experiences with microorganisms, the basic design of the human body, a sense of disease versus health, and the importance of oneself and one's own biology.

Projects abound. The stated emphasis is on both the diversity of science and the scientific endeavor. Sadly, many projects still involve copying from a book or an encyclopedia. However, the new generation of elementary science teachers is actively encouraging students to ask and answer questions, and many students have the excitement of these experiences strongly reinforced in group work, both in the classroom and at public displays of their work in science fairs.

In spite of this emphasis on the processes of science, the lists of long-term goals and guidelines for evaluation show many signs that, in the final analysis, there is a clear preference for "knowledge," familiarity with materials studied, and getting the "right answers." Curriculum planners do not expect elementary teachers to have experienced the realities of scientific inquiry, and many suggestions for investigation are contrived and unlikely to allow

the teacher and student to share the genuine experiences of discovery. Enunciation of major concepts is not a major issue. In spite of these criticisms, Canadian elementary schools are cultivating science carefully, and more and more students are receiving positive first experiences.

Biology Concepts at the Junior Secondary Level

Although most Canadian provinces allow local decisions on the overall structure of secondary school education, it is useful to consider schools as junior secondary (grades 7-8 to 9-10) and senior secondary (grades 10-11 to 12-13).

In British Columbia, the stated goals for junior secondary science are essentially the same as those for the elementary curriculum. The biological subject matter includes ecology/resources, human sensory systems and Mendelian genetics.

Work for junior secondary biology in all provinces emphasizes practical activity and investigative pursuits. There is also much anecdotal evidence and some inconclusive, but statistically controversial, work suggesting that many students in grades 7-10 get "turned off" by their science experiences in junior secondary school. The talents and skills of science teachers are severely tested in this segment of our education system.

In several regions of Canada, teachers and students have found that science fairs provide very attractive opportunities for students to grow in science. However, teachers operating with less motivated students, oversized classes, shrinking budgets, and other pressures to show parents that their children "have learned something" are often forced to retreat from the personal and intellectual commitment to investigate and to retrench at the baseline of information transfer.

The subject matter of junior secondary biology often demands that students enhance their appreciation of the fundamental concepts in biology. The biology component of BC grade 10 curriculum requires that students "use the processes of science to investigate a local resource" and "describe the genetic principles which govern the inheritance of traits." Here are two examples where understanding of biological concepts are essential for success. Sadly, we find also that a large number of the written expected learning outcomes are obvious victims of objective statements that direct teacher and student along a path towards rote learning.

Biology Concepts at the Senior Secondary Level

Senior secondary schools across Canada include at least the last two high school years, although local autonomy allows larger groupings. It is only in the last two years of high school that the traditional subject names are used in curriculum guides.

As in most countries, subject selection is driven by post-secondary aspirations, and in Canada, there is a widespread tendency to treat the last two years in high school and the first year in university/college as a three-year program. Selection of senior secondary level subjects has become something of a "notice of intent" by students. Teachers respond accordingly. In addition, in some provinces, there is a public examination administered at the end of the graduating year level (grade 12 in BC and grade 13 in Ontario) which is a major contribution (40% or more) to the student's final evaluation.

Careful analysis of curriculum guides and selected textbook resources from all Canadian provinces indicates that the opportunities ex-

ist for all senior secondary students to become acquainted with the general principles of biology. However, these principles/concepts are not clearly enunciated as goals for student enlightenment.

It is clear that the best students, many of whom will go on to the university and take further biology, emerge from their high school experience with a reasonable grasp of the major ideas. This is achieved through completion of several class assignments that require students to look for unifying ideas. Nevertheless, the internal or external examinations that are administered do not reward the thinking student, and most, if not all, students are forced to fall back on memorization of detail at the expense of retention through understanding of concepts.

Three outside influences are at work. First, the expected learning outcomes provided for teachers in the curriculum guides are dominated by the terms "describe," "explain," "identify," "list" and "define." Second, formal final examinations include a substantial number of multiple choice questions. The third, more debatable influence is the absence of significant prescribed practical activities. It is a widespread reality that many students receive, at best, perfunctory exposure to practical work during their last year in a BC high school. One BC Ministry of Education argument against practical work is that some school districts may not have the budget. Some teachers do no practical work, but others remain committed to the ideals of science education right to the end!

A survey of British Columbia senior secondary biology teachers taken in 1987, one year after the adoption of a completely new curriculum, indicated that 10-20% of these teachers did not wish to teach the process and philosophy of biological science. Out of 117 responses received from two-thirds of the school districts, 22 recommended the elimination of the core unit on experimental design from the grade 12 curriculum. Plant biology also fared badly in teacher priorities for what should be taught in senior school biology (23 recommended elimination or reduction of the core section of plant form and function).

The hostility towards botany is common, even in a province where forestry is the major industry, but the unhappiness with the teaching of the fundamental ideas of science is disturbing, especially when students have spent the previous 10 years applying the basic tenets of scientific investigation. It is tempting to suggest that this teacher attitude may reflect a deep-seated belief, presumably established during the teacher's own days as a student, that science is really the accumulation of facts.

When Do We Teach the Principles of Biology?

Neither obsession with vocabulary nor evaluation of rote recall are restricted to precollege institutions, so it may be useful to ask, "Where and how do we teach the principles of biology?"

The answer seems to be in elementary school and during late-undergraduate and graduate studies in science faculties. In the elementary school, children have a genuine wonder for the world about them and respond well to any positive efforts to help them follow their curiosity. What is more, it is clearly impossible to pack elementary school children's heads with useless and meaningless vocabulary.

In the university, we are educating the survivors for whom the interest in science has overwhelmed the negative teaching experiences of their teenage years. What is more,

their professors can provide special training and do not have classroom discipline as a major time and energy consumer of their intellectual activities. In spite of this advantage, many university professors have persuaded their faculty colleagues that we do not have the time to give all those undergraduates real science experiences. What is more, it is argued, most of the students have little talent for research, and we would thus be wasting our time. The tragedy is that third- and fourth-year biology majors are the classroom teachers of tomorrow. If they have done no science, how can we expect them to become mentors of young scientists on the basis of one or two teaching methods courses?

How Does the Nonschool Community See Precollege Biology Taught in Canada?

Almost every Canadian university offers a first-year course that allows students with no previous high school biology to enter second-year studies in biology. How is this possible? I believe that it is because the professors who are charged with accelerating inexperienced students through a beginning course are forced to emphasize the principles, and the students are forced to master the underlying ideas before they can select the information that must be learned.

Unlike chemistry and physics, the successful study of biology has no essential requirement for learning by a structured progression of increasing complexity. Indeed, while formal background in physics, chemistry and mathematics make modern biology teaching much easier, the halls of academic and professional biology are strewn with outstanding scientists who failed or never even attempted advanced study in the more formal scientific disciplines and whose first experience in biology was at the university. For example, it is my personal experience from teaching many students who do not possess normal "prerequisites" for third-year university courses in plant and cell physiology that, while quantitative skills can make biology both interesting and relatively easy, there is no substitute for a strong sense of three-dimensional space!

The challenge is to manipulate high school curricula and evaluation to reward the student who understands the principles. I naively suggest three "old-fashioned" means to this end:

1. Place emphasis on learning outcomes that can only be attained by thorough grasp of the principles.

2. Accept the fact that sound science education is essentially the same regardless of age or educational experience of the student.

3. Return to evaluation methods that demand that the students explain their understanding of information rather than be rewarded for recognition and regurgitation.

I fear that it will take a fundamental change in the way that we teach teachers if we are to take the principles to levels of school curriculum that are commonplace in language arts and quantitative sciences.

Facing New & Controversial Issues

The recent welcome arrival of bioethics in curricula reminds us that teaching and learning science include the obligation to consider the social impact of advancing knowledge. It is easy to instruct students about the fundamental need for honest reporting in science, but the social consequences of recent developments in biological knowledge require us to take a far wider look at ethics. Many of the scientific and biotechnological advances bring

biology into direct conflict with current local or global social and religious mores. A theistic code may run contrary to biological "sense," but its dismissal may, of itself, be unethical. In North America, the teaching of evolutionary theory is frequently controversial. In many cultures, current western trends toward emancipation of women or visible minorities are contrary to perceived codes of sound social order. The central question, "What is life?," lies at the core of the debate on a woman's right to determine her reproductive activity. These issues can only be addressed critically by people who grasp the fundamental biological issues. Thus, the problem expands to asking, "How can we ensure that all citizens understand the basic concepts of biology?"

Conclusions

All curricula for biology teaching in Canada emphasize attitudes, processes, knowledge and thinking of science. The few statements of goals and objectives that are specific to principles of biology are frequently reduced to low levels of intellectual attainment. This reduces rewards for students and teachers who make a commitment to learning by understanding the basic ideas. The absence of a national professional body for biology (equivalent to the Chemical Society in the UK or the Chemical Institute of Canada) may be the biggest obstruction to a national curriculum that guides curriculum designers to some unifying ideas and standards for the teaching of precollege biology.

Contributed Paper

Teaching Biology in U.S. High Schools: BSCS Perspectives on Reform

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The teaching of biology in U.S. high schools is in the process of reform. The current educational reform is the most pervasive in our history and the most significant since the "Golden Age" of curriculum development that gave birth to BSCS in 1958. Although debates about the dimensions and difficulties of reforming the biology curriculum are contemporary, the fundamental issues belong to history (Hurd 1961; Rosenthal & Bybee 1987, 1988; Pauly 1991; Rosen 1959). Current debates center on questions such as ... What biological knowledge is most important for all Americans? ... How should we organize the scope and sequence of biology? ... What is the role of the laboratory? ... And, how can we use educational technology appropriately?

A National Perspective

If the 1980s was a decade of reports, then the 1990s must be characterized as an era of educational reform through constructive action. There are mandates for changes in science education at all levels and for all disciplines, including biology (Anderson 1989; Blystone 1990; Clark 1989; Kahle 1990; Leonard, et al. 1991; Rosen 1989; National Research Council 1990). *Fulfilling the Promise: Biology Education in the Nation's Schools* (National Research Council 1990) provides a thorough review of the problems facing life science education. The list is familiar — low test scores, inadequate textbooks, poor teaching, little laboratory-based instruction, and assessment that is inconsistent with the knowledge and skills most important for students in the last decade of the 20th century. The report leaves little doubt about the dismal condition of biology education in high schools.

The problems in biology education can be reduced to the need for a reconceptualization of curriculum, instruction and assessment for biology programs at the precollege level, as proposed by the National Research Council (NRC): "The high school biology course should be a synthetic treatment of important concepts and of how these concepts can shape our understanding of ourselves and our planet." (NRC 1990, p. 6)... "We need a much leaner biology course that is constructed from a small number of general principles that can serve as a scaffolding on which students will be able to build further knowledge... The scaffolding should include an understanding of basic concepts in cell and molecular biology, evolution, energy and metabolism, heredity, development and reproduction, and ecology. Concepts must be mastered through inquiry, not memorization of words" (NRC 1990, p. 21).

The conclusion is evident: There is a need for reform of biology education programs at the precollege level. More important, reform should produce a coordinated set of experiences for those passing through high school biology. The National Research Council (1990) recommends the following for high school biology:

•In designing a course, we must identify the central concepts and principles that every high school student should know and pare from the

curriculum everything that does not explicate and illuminate these relatively few concepts.

•The concepts must be presented in a manner that relates them to the world that students understand and in a language that is familiar.

•They (biology courses) must be taught by a process that engages all the students in examining why they believe what they believe. Such a process requires ample time for discussion with peers and with the teacher. In science, it also means observation and experimentation, not as exercises in following recipes but to confront the essence of the material.

The recommendations support the use of major concepts but do not provide a conceptual framework or outline a curriculum. The recommendations also support a theme for the curriculum: that the concepts be presented in a context that has some meaning for the student. Finally, the NRC report emphasizes the importance of instruction grounded in inquiry.

The omission of a conceptual framework in the NRC report is partially remedied in reports from the American Association for the Advancement of Science (AAAS). As part of Project 2061, AAAS outlined goals in science literacy that all Americans should achieve by age 18. The goals, described in *Science for All Americans* (AAAS 1989), provide a view of biology content that contrasts markedly with that found in most current textbooks. One chapter on the living environment focuses on six major subjects: the diversity of life, the transfer of inheritable characteristics, the structure and function of cells, the interdependence of organisms and their environment, the flow of matter and energy through life cycles, and the explanatory power of evolution.

Of particular interest here is a companion volume, *Biological and Health Sciences: A Project 2061 Panel Report* (Clark 1989). This report outlines the conceptual themes and suggests, but does not elaborate, a human context for the curriculum. Sections of the report include human biology, the evolution of life, diverse life forms, environmental biology and human ecology.

Both the NRC and AAAS reports are quite helpful, but neither report (nor the two combined) provides an adequate curriculum framework for high school biology. *Fulfilling the Promise: Biology Education in the Nation's Schools* (NRC 1990) addresses the problems of precollege biology education and the impediments to change, but the report does not outline, in any detail, the major conceptual themes of biology. Nor does the report take the critical step from policy recommendations for textbooks and laboratory activities to practical suggestions for the design and implementation of new programs.

Science for All Americans (AAAS 1989) and the companion volume, *Biological and Health Science: A Project 2061 Panel Report*, review biological concepts, but leave curriculum developers and classroom practitioners with the question — "What do I do now?" That is, the report lacks a curriculum framework or model program. There are no suggestions for the organization of curriculum and instructional strategies for assessment and plans for implementation.

There are additional considerations for any new biology program. Contemporary reform must recognize and respond to the challenges raised by the diverse student population enrolling in biology classes (Vetter 1989). In the 1990s and beyond, there is a need for a biology program designed for all students, especially

those traditionally underrepresented in the sciences, such as African Americans, Hispanic Americans, Native Americans, women, and the physically challenged (Bybee & Kahle 1982; Kahle & Lakes 1983). The demand is quite high for a new biology program that focuses on the personal and social perspectives of youth and introduces the fundamental knowledge, values and skills of the life sciences.

A New BSCS Program

The Biological Sciences Curriculum Study (BSCS) is developing an innovative high school biology program that is appropriate to all students. Titled *Biological Science: A Human Approach*, this program is designed as a full-year curriculum for a first-year biology course (Grade 10, ages 15-16) taken by 95% of American students. The use of a human context for biology, the incorporation of quality laboratory investigations, educational technology and inquiry-oriented activities should make the program more engaging and improve students' conceptual understanding of biology (Carey 1986; Anderson & Smith 1986; Champagne 1989).

Biological Sciences: A Human Approach will empower biology teachers through their orchestration of instruction and their use of the technologies. Materials and investigations will be provided and core experiences will be recommended, but it will be up to the biology teacher to decide on the final sequence of activities. The flexibility of this program will empower teachers by allowing them to adapt the curriculum to the unique needs of their students and school. Allowing teachers to make final decisions about the instruction also will accommodate the variety of technologies available in the classroom and will support the increased use of technology by classroom teachers.

Biological Science: A Human Approach will be designed to achieve the following student goals:

- An understanding of basic biological concepts.
- An understanding of the role, place and interactions of humans in the biosphere.
- An understanding of science as a way of knowing and technology as a way of adapting.
- Cognitive skills, such as cooperation, critical thinking, problem solving and ethical analysis.
- Skills in the use of laboratory equipment and educational technologies.
- An understanding of the personal and social implications of biology and biotechnology.
- An awareness of the role of other disciplines, such as anthropology, psychology and health science in understanding human biology.
- An appreciation of living systems.

There also are program goals designed to help biology teachers improve their teaching. Following are some anticipated changes for biology teachers:

- Decreased dependence on a central text and increased use of a variety of instructional materials and strategies.

- Decreased use of lecture and increased use of activities including laboratory and educational courseware.

- Decreased perceptions that science is a body of knowledge and that technology is the application of knowledge, and increased understanding that science is a way of knowing and technology is a way of adapting.

- Decreased use of teacher-proof materials and increased empowerment through the decision-making process for curriculum and instruction.

•Decreased use of traditional tests and increased use of authentic science assessments, portfolios and other innovative approaches to evaluation.

Biological Science: A Human Approach will use human biology as the emphasis for the curriculum. Human biology is the scientific study of *Homo sapiens* as individuals, as a population, as part of communities, and as a species that interacts with other species and with the environment. Human biology includes the study of major biological concepts, such as energetics, genetics, regulation and homeostasis, form and function, development, behavior, ecology and evolution within the context of human systems and subsystems (Moore 1988, 1989, 1990).

Three major themes form the orientation of this curriculum:
•Understanding the characteristics of *Homo sapiens* that are unique to the species and those characteristics that we share with other living systems.

•Understanding the place of humans in the biosphere and the consequences of our interactions with the environment.

•Understanding the history of human evolution and the effects of our interactions with the environment on the evolution of other species.

Biological Science: A Human Approach will use an issue-centered approach that organizes each of seven units on a human, ecological or global problem and then develops biological concepts needed to answer the question or technological principles to solve the problem. This approach lends itself to an integration of concepts from physics, chemistry, earth science, mathematics and technology as part of answering the questions and solving the problems. In addition, the issue-centered approach requires the inclusion of perspectives from the social and behavioral sciences and from ethics and public policy. The program will consist of seven units, each of which will use traditional "wet" laboratory activities, microcomputer-based laboratories, educational courseware, computer simulations, videodiscs and the textbook. The seven units will be "The Human Species," "The Human Organism," "Human Physical Performance," "The Human Life Cycle," "The Human Population," "Human Adaptation" and "The Human Predicament." Figure 1 provides descriptions on the units.

An instructional model will orient the teachers' orchestration of instruction and students' learning in each unit. Five words characterize different approaches to instruction: engage, explore, explain, elaborate and evaluate. As students move through activities, they will have new experiences that they relate to prior knowledge. In some cases, their new knowledge will be congruent with their current explanations of how the world works. In other instances, the new experiences will conflict with the students' current understanding of their world. In the latter case, the students will work with the teacher and with each other to build new explanations for those experiences. In this way, students will reconstruct their knowledge about the world and make it more meaningful and more useful to them.

The types of strategies used in the curriculum include:
•Cooperative learning.
•Experiences that encourage the development of spatial and cognitive processing skills.
•Introduction to careers in biology and biotechnology.
•Topics that are relevant to the students' lives and activities that build on all students' prior

THE HUMAN SPECIES

What does it mean to be human? This is the central question of the unit. The unit will begin when the students assess the range of diversity of organisms and examine the ecological relationships among populations while trying to place humans in the scheme of living systems. The unit will introduce students to characteristics that are common to all living systems and to characteristics that are unique to humans and will present basic conceptual themes of biology, such as evolution, diversity and genetic variation. The unit will also acquaint students and teachers with the technologies (for example, microcomputer-based laboratories and computer simulations) and the instructional strategies (for example, laboratory investigations and cooperative learning) used in the program. In this unit, and the following units, students will be introduced to the major concepts in biology and the methods of scientific inquiry and technology problem solving. The program also will introduce students to ethical issues.

THE HUMAN ORGANISM

This unit will begin when students try to explain a simple medical problem such as an upper-respiratory infection. Explaining the medical problem will introduce students to major concepts, such as systems, structure and function, and homeostasis and regulation. Topics will include the cellular basis of life, human systems, control of the internal environment, internal transport, gas exchange, nutrient procurement, exercise and cardiovascular disease, prevention and control of infection, and basic functions of the human body.

HUMAN PHYSICAL PERFORMANCE

This unit will begin with the students trying to explain the requirements of athletic performance. The major concepts of the unit will be energy and metabolism and physical and mental health. The unit will develop an understanding of the role played by the muscular, skeletal, endocrine and nervous systems. Topics of study will include posture, movement, nervous and hormonal control, homeostatic responses during exercise, regulation of the composition of body fluids, and the influence of fitness, drugs and alcohol on performance. In addition, the unit will address the notion that one can improve performance through technology, for example, better equipment and through technology such as steroids; but, the latter raises biological, social and ethical issues.

THE HUMAN LIFE CYCLE

This unit will center on the genetic and environmental influences during the course of human development. Major conceptual themes will be reproduction, development and genetic continuity. The students also will recognize the changing needs of individuals at different stages in the life cycle. Topics will include reproduction and inheritance, the reproductive system, hormonal regulation, pregnancy, infancy and childhood, predicting a human's characteristics through DNA analysis, adolescence, adulthood and aging.

THE HUMAN POPULATION

This unit will introduce the general problem of population growth and human evolution. After the introduction, the students will consider the physical and cultural evolution of humans and the genetic basis for human variations, the role of technology, and bioethical issues. Human evolution will be the major conceptual theme of the unit. Cultural evolution and the power it gives us to affect the biosphere will be emphasized. Topics in this unit will include genetics and evolution, human variation, lifestyle, and human adaptation through technology and information systems.

HUMAN ADAPTION

This unit will focus on biotechnology, broadly defined, and use a historical approach to develop the themes. The students will investigate the constraints that nature places on human activities and will introduce technology as the primary means that humans use to adapt to the environment. The unit's central theme will be the contrast between biological and technological solutions to problems of human adaption. Technology will be introduced as the application of knowledge, tools and skills to solve problems. Simple technologies of early humans will be compared with complex technologies of contemporary societies. Basic conceptual themes will include systems, adaptation, and structure and function. Topics will include domestication of plants and animals; tools; health technologies; medical technologies; interaction of population, technology and environment, genetic engineering, and ethical and public policy issues.

THE HUMAN PREDICAMENT

The students will address a contemporary social issue directly related to biology. The unit will center on issues in the major conceptual area of human ecology including dilemmas about the interactions among populations, resources and environments. The unit also will include related issues, such as control and prevention of widespread disease and differential effects of these issues on various groups within society and in different countries. Topics will include population dynamics, resource depletion, environmental degradation, quality of life, and the role of biological, political, economic and technological solutions. The unit will not be an exclusively Western view of the human predicament. We will show students that problems in other countries are both similar to and different from those in this country.

Figure 1. The instructional units for *Biological Science: A Human Approach.*

experiences.
•Activities that promote critical thinking.
•Reinforcement of basic skills that will increase the students' chances of success in school.
•Language and art work that include a balanced representation of gender and race.

The development of a biology curriculum emphasizing *Homo sapiens* is supported by the NRC recommendation that "concepts must be presented in such a manner that they are related to the world that students understand in a language that is familiar." *Science for All Americans* (AAAS 1989) also provides support for a human approach to biology in the chapter titled, "The Human Organism" and in the recommendation that topics such as human identity, the life cycle, the basic functions of the body, and health be considered integral to scientific literacy.

Turning Points: Preparing American Youth for the 21st Century (Carnegie Council 1989) is another national report that recommends a human focus for life science education. The report emphasizes the challenges and choices many adolescents face, chief among them decisions about health, drugs and alcohol. In addressing the curriculum for early adolescents, the report states:
"The core program can capitalize on young adolescents' concerns and curiosity about their own physical and emotional development and their place within the family, peer group and larger society. Thus, the life sciences, which link biology, physiology, genetics, human evolution and behavior to health education, could be clustered around themes related to the developing adolescent" (p. 48).

Prologue to Action: Life Sciences Education and Science Literacy, a 1992 report from the United States Public Health Service, further underscores the need to focus life sciences education on themes that include students' understanding of sciences in the service of humankind and in the practice of personal living.

The types of problems we wish students to address in the human biology program — and the skills the program will help develop — are not, of course, constrained by national boundaries. Although the details of content likely would differ from country to country, given local issues and the differences in the flora and fauna that constitute the context of human interactions with the environment, we believe the program we propose has broad application internationally. We welcome the opportunity to collaborate with scientists and educators in other countries and regions to develop a program that can help prepare all the world's children for life in the 21st century.

References

American Association for the Advancement of Science. (1989). *Science for all Americans.* Washington, DC: Author.

Anderson, C.A. & Smith, E. (1986). Teaching science. In V. Koehler (Ed.), *The educator's handbook: A research practice.* New York, NY: Longman.

Anderson, O.R. (1989). *The teaching and learning of biology in the United States.* Second IEA Science Study. New York, NY: Teachers College, Columbia University.

Blystone, R.V. (1990). *Learning resource issues in biology.* A commissioned paper for the U.S. Department of Education FIPSE/FIRST Partnership Conference, 17-18 September. Washington, DC.

Bybee, R.W. & Kahle, J.B. (1982). Biology education: Beyond the status quo. In F.

Hickman & J.B. Kahle (Eds.), *New directions in biology teaching.* Reston, VA: National Association of Biology Teachers.

Carey, S. (1986). Cognitive science and science education. *American Psychologist, 41,* 1123-1130.

Carnegie Council on Early Adolescents. (1989). *Turning points: Preparing American youth for the 21st century.* New York, NY: Carnegie Corporation of New York.

Champagne, A.B. (1989). Changing conceptions of the learner's implications for biology teaching. In W. Rosen (Ed.), *High school biology: Today and tomorrow.* Washington, DC: National Academy Press.

Clark, M. (1989). *Biological and health sciences: A Project 2061 report.* Washington, DC: American Association for the Advancement of Science.

Hurd, P.D. (1961). *Biological education in American secondary schools 1890-1960.* Washington, D.C.: American Institute of Biological Sciences.

Kahle, J.B. (1990). *Issues in instruction: Biology.* A commissioned paper for the U.S. Department of Education FIPSE/FIRST Partnership Conference, 17-18 September, Washington, DC.

Kahle, J.B. & Lakes, M. (1983). The myths of equality in science classrooms. *Journal of Research in Science Teaching, 20,* 131-140.

Leonard, W.N., Fowler, C., Mason, C., Ridenour, N. & Stone, C. (1991). A minimum core curriculum for introductory high school biology. *The American Biology Teacher, 53*(7), 400-405.

Moore, J.A. (1988). *A conceptual framework for biology - Part I.* Washington, DC: American Society of Zoologists.

Moore, J.A. (1989). *A conceptual framework for biology - Part II.* Washington, DC: American Society of Zoologists.

Moore, J.A. (1990). *A conceptual framework for biology - Part III.* Washington, DC: American Society of Zoologists.

National Research Council. (1990). *Fulfilling the promise: Biology education in the nation's schools.* Washington, DC: National Academy Press.

National Science Board. (1983). *Educating Americans for the 21st century.* Washington, DC: National Science Foundation.

Pauly, P.J. (1991). The development of high school biology. *ISIS, 82,* 662-668.

Rosen, S. (1959). Origins of high school general biology. *School Science and Mathematics, 59*(60), 473-489.

Rosen, W.G. (Ed.). (1989). *High school biology: Today and tomorrow.* Washington, DC: National Academy Press.

Rosenthal, D.B. & Bybee, R.W. (1987). Emergence of the biology curriculum: A science of life or a science of living? In T.S. Popkewitz (Ed.), *The formation of the school subjects,* pp. 123-144. Philadelphia, PA: The Falmer Press.

Rosenthal, D.B. & Bybee, R.W. (1988). High school biology: The early years. *The*

American Biology Teacher, 50 (6), 345-347.

U.S. Public Health Service. (1992). *Prologue to action: Life sciences education and science literacy.* Report of Public Health Service National Conference in June 1991, Columbus, OH.

Vetter, B. (1989). Look who's coming to school. Changing demographics: Implications for science education. In *Curriculum development for the year 2000,* pp. 1-12. Colorado Springs, CO: Biological Sciences Curriculum Study (BSCS).

Contributed Paper

Basic Biological Concepts: The Caribbean Situation

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Introduction

The purpose of this paper is to examine the biology topics and concepts taught at school level in the Caribbean. This presentation gives a list of the basic biological concepts to which learners throughout the system are exposed and, by implication, suggests the ones which biological educators believe to be most important.

In the Caribbean, the teaching of science officially begins at the age of five — at the beginning of the primary level. The primary level concludes at the age of 11+, and throughout this level, science is integrated/unified with heavy emphasis on the process of science. The biological component, though fairly heavy, is not explicit but forms part of such integrating themes as "energy" and "environment."

The integrated science continues into the first part of the secondary level — junior secondary level (11+ to 14+ age range). In the second part of the secondary level, there are two strands possible in science: (1) biology, physics or chemistry to 16+ and (2) integrated science (single award) to 16+. Further work in science continues as biology, chemistry and physics through the first and second stages of sixth forms and university.

In the case of science at teachers' training colleges, there is an integrated program for prospective primary and secondary teachers. These two programs differ in level and depth of treatment.

This presentation takes the various levels of the system — primary, lower secondary to 14+, upper secondary to 16+, and teachers' colleges — and examines each for the biological concepts taught. The main sources of information about the concepts covered at the various levels are curriculum materials, popular textbooks and examination syllabi.

Biological Concepts at the Primary Level (5–11 years)

Although science at this level in the Caribbean is integrated, there are certain aspects of biology that are taught from the earliest ages. Invariably, such topics are heavily oriented towards biology and its impact on society and the environment. The following represents some of the typical topics covered in curriculum at this level which emphasize aspects of biology.

Age Range: 5 – 7 years
Movement, senses and observation, health and safety, useful plants and animals.

Age Range: 7 – 9 years
Plants and animals, health and safety, pollution and conservation.

Age Range: 9 – 11 years
The body and how it works, food preservation, man and his environment, reproduction, drugs — use and abuse.

Biology at the Junior Secondary Level (11–14 years)

Although the program is an integrated one, aspects of biology stand out in the varying degrees of integration that have been achieved. The textbooks examined comprise a two-volume effort to provide concepts for lower secondary students. The topics and subtopics are as follows:

Book 1

Detecting Our Environment — What is the environment? ... Senses and stimuli ... The eye and how it works ... Focusing on near and far objects ... Spectacles ... Are two eyes better than one? ... Seeing colors ... Extending sight ... Ultrasonics to aid the disabled ... The ear structure and function ... The human voice and how it works ... Touch, smell and taste ... Nerves and brain.

Support and Movement — Support in plants ... Support of movement in animals ... Stability ... Support in water and air ... Muscles ... Animals and external skeletons ... Soft-bodied invertebrates.

Animals, Plants and their Environment — The environment ... Habitats and communities ... Identifying animals ... The physical and biological environment ... Competition ... A closer look at plants and animals in the school ground ... Important features of the soil ... The sandy seashore ... A swamp ... The big ecosystem ... Pollution.

Food, Nutrition and Health — Food in the Caribbean ... Why do we need food ?... Types of food ... Measuring energy from foods ... A balanced diet ... Digestion, absorption, enzymes ... Comparing mammal's teeth ... Caring for teeth ... What makes teeth decay? ... Why preserve food? ... Bacteria and food spoilage ... Fungi ... Organisms and the transfer of bacteria.

Book 2

Looking at Living Things — Sorting things out ... The big difference between animals ... Features of vertebrates ... Similarity and variety ... Looking at birds, mosquitoes, butterflies ... Keeping invertebrates in the laboratory ... Classifying plants ... Looking at trees and flowers ... Watching seeds grow ... Seed dispersal.

Cells and Organisms — Looking into plant and animal cells ... Cells and organisms.

Reproduction and Growth — Cell and reproduction ... Sex cells in plants and animals ... Animal embryos and their development ... Plant embryos ... Parental care.

Air and Living Things — The atmosphere (constituents and uses) ... Breathing (exhaled and inhaled air) ... Effects of exercise ... Oxygen and cells ... How do fish breathe? ... Plants and foodmaking ... Food chains and food webs.

A recent attempt at producing a curriculum for the 11–14 age range in a Caribbean country has suggested the following concepts/specific objectives. These should be looked at alongside what the textbooks offer.

Under the topic, Variety of Life, the students should be able to:

- Identify local plants and animals.
- State the characteristics of living things.
- Develop a willingness to collect materials for observation and identification.
- Develop the ability to observe and record accurately.
- Group organisms on the basis of similarities and differences and to use keys to identify them.

Under the topic, Processes of Life, the students should be able to:

•State that the cell is the unit of structure of all organisms.
•State that the cell can divide, and this is the simplest form of division.
•Use the microscope in the study of cells.
•Outline the conditions necessary for germination to take place.
•Recall the main parts of a simple flower.
•Recognize and name the parts of the seed and the stages through which a seedling passes.
•Recognize the importance of pollination and fertilization.
•Relate the form of an organ and organism to their functions and life cycles.
•Define cellular respiration.
•List several types of respiratory organs.
•Label the organs/parts of the respiratory system of man.
•Explain the mechanism of breathing.
•Be aware of other types of respiration, e.g. anaerobic respiration and the importance of related industries.
•Investigate the requirements for photosynthesis in green plants.
•List the products of photosynthesis and tell the importance of each to animals.
•Construct food chains and simple food webs.
•Trace the flow of energy from one organism to another.
•Define and identify producers, consumers and decomposers; herbivores, carnivores and omnivores in a food web.
•Define the terms: environment, habitat, niche, community, ecosystem.
•Define biotic and abiotic factors and list examples of each type.
•Define pollution.
•List the major forms of pollution and list the effects of water, noise and air pollution on life.
•List the various forms of support and movement in living organisms.
•Identify the various parts of the human skeleton.
•Explain that muscles pull on bones and cause movement.
•Identify and label the various components of a typical plant and animal cell.
•Compare and contrast the structures of a typical plant and animal cell.
•Recognize various types of cells and relate their specialization to their function.
•Recognize the relationship between cells, tissues, organs, systems and organisms.
•Investigate variation between individuals in a range of living organisms.
•List the different classes of food and use this information to describe a balanced diet.
•Identify local foods that are good sources of each food type.
•Recognize that an unbalanced diet may lead to disease and relate specific deficiency diseases (and their symptoms) to lack of specific nutrients.
•Discuss other nutritional disorders, e.g. obesity.
•Draw and label the digestive system of man and state the function of each part (including teeth).
•Explain the necessity and process of digestion.
•Explain the process of absorption and elimination.
•Perform food tests.
•Recognize the role of micro-organisms in biological systems (e.g. diseases in plants and animals; spoilage of food).
•Distinguish between excretion and egestion.
•List the waste products of a mammal and the respective excretory organs.
•Briefly explain the mechanism of excretion by the skin, lungs and kidneys.

Under the topic, Earth and Atmosphere, the students should be able to:

•Recall the natural water cycle.
•Define and demonstrate the processes of

evaporation and condensation.
•Discuss the importance of water to life.
•Describe the following methods used to purify or clean water — filtration, settling, distillation.
•Distinguish between clear and pure water.
•Distinguish between solute, solvent and solution.
•Recall the composition of air and the percentage of gases present.
•Describe the tasks that can be used to identify oxygen, carbon dioxide and hydrogen.
•Describe the process of distillation that is used to separate the gases commercially.
•Recall how each gas is used in the modern world.
•Discuss the problems associated with carbon dioxide emissions with special reference to acid rain and the greenhouse effect.
•Discuss the effects of aerosol sprays on the environment with special reference to the ozone layer.
•Discuss the coastal problems associated with soil erosion.
•Discuss environmental issues associated with tourism.
•Discuss the problems associated with oil, chemical and garbage discharges into the sea and onto coastal beaches.

Under the topic, Energy Resources, the students should be able to:
•Recall the conditions that are necessary for photosynthesis to take place.
•Discuss the importance of photosynthesis to life on Earth.
•Recall the importance of light and chlorophyll in the process of photosynthesis.

Under the topic, Genetics and Evolution, the students should be able to describe the role of chromosomes and genes in the transfer of hereditary characteristics from parent to offspring.

Under the topic, Sound and Music, the students should be able to:
•Explain how animals make sounds.
•Label and explain the functions of the main parts of the ear (including balance).
•Cite common ear defects, their causes and corrective measures.
•Discuss the effects of noise pollution.

Under the topic, Light, the students should be able to:
•Draw and label the eye, relating its structure to its functions.
•State common defects of vision and corrective procedures.
•Discuss the care of the eye.

Biology Education at the Senior Secondary Level (14–16 years)

The opinion was expressed earlier that biology teaching in schools in the Caribbean is greatly influenced and controlled by examination bodies and textbooks. At the 14-16 age range, students are being prepared for examinations which will give them a passport to the job market or further study in the subject. It is perilous to miss this boat.

In the last few years, the region developed its own secondary school-leaving examination capability — The Caribbean Examinations Council (CXC). Out of the activities of a group of biologists and biology educators has emerged a syllabus, which represents, or ought to represent, the latest thinking about biology education.

Those involved in biology education at all levels waited anxiously for a document that would make the study ecologically relevant to Caribbean peoples. With all due respect to external examination bodies, it was felt that this syllabus would remove all the concerns and imperfections about which everyone com-

plained so bitterly.

Many of the concerns have been redressed, many fears allayed, but there seem to be certain aspects that need to be put right. There are definite attempts to follow some of the trends of international biology education, but a lot more needs to be done.

The CXC Biology Syllabus

The syllabus begins by providing a rationale for the study of biology. The case is made that biology is relevant to every individual and that there is a need to generate a concern for all life and develop an attitude of responsibility for the total environment. Biology also promotes an awareness of the dynamic nature of scientific ideas and an appreciation for the breadth of science.

From this rationale, the general goals of the syllabus are to:

- Develop an understanding of fundamental biological principles and concepts based upon practical and theoretical knowledge of living organisms.
- Develop a natural curiosity about living organisms without encouraging their unnecessary disturbance and/or destruction.
- Recognize the dynamic nature of the interrelationships between organisms and their environments.
- Recognize the social and economic implications of biology.
- Apply biological knowledge to everyday life situations.
- Make accurate observations of biological material and phenomena, both in the field and in the laboratory.
- Develop an ability to record information accurately by means of clear, labeled diagrams, graphs, tables, etc.
- Formulate hypotheses and design and carry out experiments to test them.
- Assess and interpret simple biological experiments and data.
- Develop and practice problem-solving skills.
- Develop an awareness that principles of chemistry, physics and mathematics are necessary for proper understanding of biology.
- Appreciate that, although generalizations have predictive value, there are often exceptions to them.
- Develop a respect for living things.

Explicit in these statements are some key biological concepts (e.g. the interrelationships between organisms and their environments, social and economic implications of biology, application of biological knowledge to everyday life, development and practice of problem-solving skills, and respect for living things and the environment).

The content areas are organized into five sections, each of which has subsections (as deduced from the specific objectives).

Section A — Living Organisms in the Environment ... This section focuses on the diversity and similarly of forms in living organisms, the interdependence between living organisms and their environments, energy flow through living organisms within the ecosystem, and the recycling of substances in nature.

Section B — Life Processes ... This section contains the usual biology topics that may be considered the basic concepts of what is life, how it is perpetuated, etc. This is by far the largest and possibly the heaviest weighted section.

Section C — Continuity and Variation ... Among the basic topics — like structure and function of cells, role of mitosis, and asexual and sexual reproduction — there are topics that seem to slant towards the use of biological

knowledge for improved efficiency in agriculture and food production, such as mechanisms through which variations in organisms originate and are inherited and the importance of genetic variations in species.

Section D — Disease and Man ... This section recognizes that several diseases common in the Caribbean affect the quality of life of its people (e.g. venereal diseases and alcoholism), the efficiency of its human resources (e.g. deficiency, vector-borne and physiological diseases), and its economy (e.g. reducing agricultural production).

Section E — Environment and Man ... This section focuses on the importance of soil to living organisms, ecology and the effects of man's activities on the environment, including an appreciation of the finite nature of the world's resources.

Emphasizing the importance of practical work and the scientist's approach to the task, the syllabus puts a section of "Practical Work" at the beginning. "The historical development of science shows that originally acceptable solutions are continually being modified in the light of new knowledge and new technology. No solution is final and infallible. What is important, therefore, for the students to acquire are the skills of problem-solving." (*CXC Biology Syllabus*, p. 8)

Topics in Popular Biology Textbooks at 16+

To complete the picture about topics in biology education in schools in the Caribbean, the author carried out an analysis of three of the more popular biology textbooks recommended and used in schools. The intention here was to identify some of the topics already outlined at the various levels of the school system, especially at the CXC (16+) level (see Table 1).

There seems to be a definite trend in the move away from merely descriptive biology in some textbooks. For example, the feeling about Textbook B is very sharply divided between two poles — one that feels that it has too many practically-oriented exercises and not enough "facts," and another that sees the practical orientation as being exactly what biology education is all about.

This author feels that the textbooks are still too slow towards reflecting international trends and some of the trends of the biology education profession. The trend towards the sociocultural aspects of biology for everyday living are still being overlooked, and these need immediate redress.

Basic Biological Concepts in Integrated Science at 16+

The *CXC Syllabus* in integrated science is divided into four parts:

- Section A — The Home.
- Section B — The Workplace.
- Section C — Recreation.
- Section D — Transport.

Each section takes the particular area of living and outlines the science embedded. The basic biological concepts are spread throughout all sections, with a predominance in Section A. The general objectives that are related to the biological concepts are as follows:

Section A — The Home

Candidates should demonstrate:

•A knowledge of simple phenomena that are fundamental to the understanding of how the organism functions.

•An understanding that life can be recognized by certain physiological characteristics.

•An understanding that different parts of the organism show structural features that facilitate particular functions.

Topics	Book A	Book B	Book C
Food & Nutrition	How animals feed: nutrition, carbohydrates, proteins, fats, vitamins, minerals, water, roughage. Balanced diet. Digestion. Teeth, the alimentary canal. Absorption. Heterotrophic nutrition. Parasites. How green plants feed.	Food classes. Energy value. Preparation, preservation, poisoning.	Animals as food; diet and food. Plants as food. Preservation of food, spoilage, tests for substances. Energy in food substances, storage.
Health & Nutrition	Pathogens cause disease. Antibodies and immunity. Infectious diseases: influenza, smallpox, tuberculosis, gonorrhea, AIDS.	Health and population. Statistics - life expectancy. Results of man's population growth. Air pollution. Pollution of seas, beaches and swamps. Conservation. Diseases and bacteria; viruses; protozoa and fungi; transmissions; population checks; deficiency; hereditary or genetic; physiological - diabetes and hypertension.	Health and disease; infectious disease; disease due to parasitic worms; fungal diseases; immunity to disease; inherited diseases; sexually transmitted diseases.
Agriculture	Soils—formation, components. Types of soil.	Agriculture and population growth. Soil: organisms, type, acidity and alkalinity, fertility. Conservation.	Soil: acidity and alkalinity; composition and formation; kinds of soil; water-logged soils. Soil conservation.
Environment & Environmental Conservation	Living organisms in the environment: energy relationships, studying ecosystems, man in the ecosystem.	Environment: pollution, conservation. Organisms in their environment: water, carbon, nitrogen, sulphur cycles; distribution and factors affecting it; methods of investigation; study of a single species. Food chains and webs. Population.	Man's effect on the environment; air; pollution; water and noise; land pollution; radiation. Man's long-term effects on the environment. Ecosystem.
Human Biology	Life processes.	Life processes.	Life processes.

Table 1. Topics covered in popular textbooks at 16+.

•An understanding that the physiological processes of an organism are coordinated and interdependent.
•Knowledge of the effects of the malfunctioning of some physiological processes.
•An ability to carry out experimental procedures to illustrate certain life processes.
•An ability to construct diagrams to illustrate certain processes.
•An awareness of diseases transmitted by household pests.
•An understanding of the need for proper sanitation in the home.
•An awareness of the debilitating effect of parasitic diseases on the organism and that such diseases can lead to economic losses.
•A knowledge of the methods of prevention and control of parasitic diseases.
•An awareness of the limitations to the effective use of pesticides.
•An understanding of the fundamental role of water in the home, the human body, and in nature.
•An understanding of the need to develop conservation habits in the everyday use of water in the home.
•An understanding of the need to minimize hazards by proper maintenance of the home.
•A knowledge of the proper treatment of accidents in the home.

Section B — The Workplace
•An understanding that physical conditions contribute to the performance and well-being of workers.
•An awareness of occupational hazards and an ability to suggest the precautionary measures that should be taken.
•An understanding that the soil and the sea are important natural resources and ecosystems, and should be preserved and conserved.

Section C — Recreation
•An awareness of some positive and negative aspects of leisure and recreational activities as regards the well-being of the individual and of the society.

Section D — Transport
•A knowledge of methods employed to protect, defend and repair the blood and nervous systems of a mammal.
•An ability to use the knowledge related to the protection, defense and repair of the blood and nervous systems in the promotion of good health.
•A knowledge of nitrogen, carbon, oxygen and water cycles occurring in nature.

Biological Concepts at 18+ (Advanced Level)
The syllabus is divided into two parts:
•The Core syllabus has six core components — cellular activities; genetic control and inheritance; reproduction, inherited change and evolution; energetics; ecology; and regulation and control.

•The Options have six components of which the candidate must study three. The options are diversity of organisms; applied plant science; application of genetics; growth, development and reproduction; human health and disease; social issues in contemporary society.

The subject content of the Core syllabus should give an indication of the types of basic concepts required.

Cellular Activities
•The cell is the fundamental unit of living organisms with the ability to carry out life processes, and its subcellular components are well-organized.
•All cells have a similar chemical composition comprised of carbohydrates, lipids, proteins, inorganic ions and water.
•Metabolic activities are controlled by enzymes.

•DNA is the genetic material.
•DNA is a double-stranded molecule capable of replication.
•Mitosis is a process involving duplication of chromosomes and their equal division into two daughter cells.

Genetic Control & Inheritance
•Information is coded in the base sequence of a single strand of DNA.
•DNA is transcribed to mRNA and translated into specific sequences of amino acids.
•One gene carries the information to produce one polypeptide.
•Meiosis is a process involving duplication of chromosomes, two divisions of the nucleus, and the formation of four haploid cells.
•Fertilization produces new combinations of alleles.
•Discontinuous and continuous variation is a characteristic of living organisms.
•Inheritance has a particulate nature.
•The expression alleles influence phenotype.

Reproduction, Inherited Change & Evolution
•Nuclear division is involved in the production of new individuals.
•Genes may mutate, and the rate is increased by ionizing radiation and some chemicals.
•Chromosome mutation produces a major change in the genome.
•Gene and chromosome mutations contribute to evolutionary change.
•Overpopulation of offspring leads to differential survival and reproduction.
•Selection may cause changes in gene frequency.

Energetics
•Cells require a controlled supply of energy and nutrients to function and survive.
•Light energy from the sun is converted to chemical energy in green plants.
•ATP and reduced NADP (NADPH) are used to convert carbon dioxide to carbohydrates: (1) by the C_3 pathway; (2) by the C_4 pathway.
•The concept of limiting factors.
•Carbohydrates and other organic compounds in plants are the initial energy sources of heterotrophs.
•Glucose is broken down to supply energy for metabolism in stages: (1) glycolysis, (2) the tricarboxylic acid [Krebs] cycle, (3) electron transport, (4) anaerobic respiration.
•ATP is the link in cellular energy transfer.
•The localization of the respiration reactions in the mitochondrion.
•Muscular contraction is an example of work.

Ecology
•Recognition of different levels of ecological organization.
•Nutrients are recyclable.
•Energy flows through the ecosystem in a linear fashion and is lost.

Regulation & Control
•There is a need to maintain a constant internal environment in cells and in all living things.
•In multicellular animals and plants, there is a need for: (1) a gaseous exchange system; (2) a transport system.
•There is a need for compounds to enter cells.
•Control and coordination in mammals involves: (1) the endocrine system, (2) the nervous system.
•Waste materials are produced by, and must be removed from, cells and organisms.

Establishing Consensus & Ongoing Re-evaluation of Content & Objectives
The concepts and objectives that are listed above, although in some cases representing a particular country, generally exist throughout the region.

At the primary level (5 to 11+), the present generation of curriculum projects is understandably similar in the content/concepts/objectives that each espouse — understandably because countries are quite similar in their background, ecology, etc. Where peculiarities exist, the programs are modified to account for this.

At the lower secondary level (11+ to 14+), the main ideas were derived from a regional project in the 1970s. The programs are now being revised using adapted ideas from the topics and objectives produced by the National Curriculum thrust in the United Kingdom.

The upper secondary level (14+ to 16+) concepts and objectives have consensus in that they were produced by CXC, the examining body for the English-speaking countries in the region. The Council impaneled teachers and educators from the region who formulated the syllabi. The procedure followed before the first examination was to circulate the syllabi for reaction and feedback from classroom teachers. Indeed, there is a mechanism built in to provide constant feedback, with the subject panels reviewing each syllabus every three years.

As far as the A-Level Biology is concerned, this again has been developed by the Cambridge Examination Syndicate of England. These are the topics/concepts that are taught by all countries and covered by their examinations. Here again, there is a built-in mechanism for receiving feedback and periodic updating. At all levels, there is consensus as to the value of these concepts/objectives. There is also in every country — and sometimes at the regional level — the mechanism for updating and re-evaluation.

Implementation of the Biology Content/ Concepts/Objectives

As is to be expected in any process of curriculum innovation, the success of implementation varies from country to country in the Caribbean. Generally speaking, the content/objectives at the school levels that lead to external examinations are the most effectively implemented. This is understandable in a region where good examination results are at a premium.

Teachers, students and parents are enthusiastic about the teaching of the proposed biological knowledge, skills and attitudes, if and when their views are sought. It is not uncommon to have materials developed by a small representative group of teachers from the system. The materials are then disseminated to the whole system. The practice of involving classroom teachers in the development helps to facilitate implementation since the practitioners see themselves as having a stake in the implementation.

One problem that implementation faces, however, is the unavailability of appropriate instructional materials and resources. Textbooks are the main printed instructional materials in use. These are usually plentiful, but cost may prevent teachers and students from procuring them. As far as the resources for teaching — equipment, facilities, etc. — are concerned, there is great deficiency. The persistent problem of lack of finances manifests itself in the scarcity of resources at all levels of the system. True, improvisation should be encouraged, and is, but there is need for the basic resources to make instruction meaningful and effective.

Perhaps the greatest limitation to implementation is the lack of sufficient teacher preparation. As a matter of fact, the scarcity of teachers both qualitatively and quantitatively curtails

the success of implementation. Part of the reason is due to the fact that the throughput from the secondary system is insufficient, but the poor terms and conditions in the teaching profession are also important factors. The number of secondary graduates who are attracted to teaching, receive professional and academic training, and remain in teaching is so small as to put the success of implementation of biological concepts and objectives at great risk. Some solution to the problem must be found urgently.

Thus, it seems that, although there is consensus as to what to teach and generally how to teach it, certain factors impede actual teaching/learning.

Summary

This brief paper attempts to outline the types of biological content/concepts/objectives that have been identified and implemented in English-speaking Caribbean schools. The level of consensus achieved among the stakeholders in the programs is investigated, and the various problems that limit effective implementation are explored.

Contributed Paper

Precollege Biology Education in Argentina: A Preliminary Report

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Introduction

Basically, Argentina's educational system is set up in, at least, three levels — primario (elementary school), secundario (high school), and universitario (university). Only the elementary level (seven years) is compulsory. The adult literacy rate is 92%.

Each province or state (23 in total) is free to draw up its own curriculum (except for the university level). That means that operational plans for instruction vary greatly. Futhermore, there are situations that increase this variation of the curriculum even more:

•There are some universities that include an elementary school and a high school as part of their institutions.

• Municipalities, like the federal capital, sometimes have their own group of schools.

The central government also has a system of elementary and high schools, but these schools are in the process of being transferred to the provinces where they are located.

This extraordinary variation of the curriculum makes it difficult to present a single report on precollege biology education in Argentina. However, most of the Argentine population is concentrated in the province of Buenos Aires. Therefore, a brief presentation of the educational system of this province, as far as biology is concerned, will be illustrative of what students should know and be able to do in biology as a part of precollege training in Argentina.

Biology in Elementary School (Educación Primaria)

The elementary school is compulsory and goes from ages 6 to 12 in a seven-year period. The Buenos Aires province has an operational plan for instruction in the elementary school that has been in place since 1986. Biology is under the heading "Natural Sciences."

The curriculum rests on two major objectives:
• To provide equal educational opportunities for every person.

• To insure, in quantity and quality, a compulsory general education for everyone.

The rationale of the curriculum is based on the logic of science and the cognitive development of students. The scientific method is adapted as a didactic method, and two stages of cognitive development are recognized: concrete (6 or 7 to 11 or 12 years old) and formal (11 or 12 to 14 or 15 years old). The key of the concrete stage is activity related to the manipulation of hypotheses or propositions. The formal stage is related to the child's ability to deal with the hypothetical.

Ten unifying principles of biology are the basis for organizing the curriculum — genetic continuity of life; organic evolution; diversity and unity of life; relationships between structure and function, and between organization

and activity; living beings and environment; biological roots of behavior; regulation and homeostasis; man and biological equilibrium on Earth; science as search for knowledge; and the history of biological concepts.

These 10 "principles" are viewed in two dimensions, contents and levels of organization. Contents include five major groups of organisms: Protista, Monera, Fungi, Plantae and Animalia. Levels of organization include atoms, molecules, cells, tissue, organ, organ systems, individual, population communities, ecosystems, Earth, planetary system.

In total, 222 activities/objectives are proposed. They are organized in two levels according to the cognitive development of students.

• Level 1 — Discovering chronological, spatial and causal relationships of the natural and cultural process (from first to fifth grade).

• Level 2 — Applying chronological, spatial and causal concepts in the exploration of the environment (6th and 7th grades).

On the other hand, the activities/objectives are organized in eight classes according to the subject of study:

•Organism structure (i.e. describe the respiratory process in plants—4th and 5th grades).
•Community structure (i.e. identify interspecific relationships, symbiosis, mutualisms, parasitisms and commensalisms—5th grade).
•Ecosystem structure (i.e. experimental activity probing the importance of the sun for the plants—5th grade).
•Earth structure (i.e. describe environmental characteristics of seasons—6th grade).
•Planetary system structure (i.e. identify evidence that demonstrates the shape of Earth through experiences—3rd grade).
•Cell structure (i.e. identify the cell as the basic unit of living beings—7th grade).
•Molecule structure (i.e. describe the elements that form a molecule—7th grade). Atom structure (i.e. describe the organization of the atom—7th grade).

Students spend around five hours per day (five days a week) in school, and each activity period lasts 40 minutes. Natural Sciences takes an average of 120 minutes a week. Thus, a period accounting for only 6-10% of total school hours is dedicated to the teaching of biology in elementary school.

Biology in the High School (Educación Secundaria)

The secondary school is not compulsory and goes from ages 13 to 17 (or 18) in a period of five (or six) years.

The Buenos Aires province has a curriculum that has been in place since 1986. Biology is under the general heading "Natural Sciences." The first three years of the instructional plan are considered the basic period. The fourth and fifth years are the higher level, and the student must choose among three areas of specialization: economics, science and pedagogy. An optional sixth year is an in-depth study of the area of specialization.

The students spend around five hours per day (five days a week) in school, and each activity period lasts 40 minutes. Natural Sciences takes an average of 80 minutes a week. Thus, a portion of time accounting for about 5-10% of total school hours is dedicated to the teaching of biology in high school.

First Year ... Natural Sciences in this year is under the heading of Introduction to Experimental Science, with a clear orientation to

biology. The content is organized around the concept of structure. The following structures constitute the basis of the instructional plan: earth, ecosystem, community, organisms, molecules, atoms and cells. Fifty-nine activities/objectives are proposed (i.e. describe the structure and function of a unicellular organism by microscopic observations).

Second Year ... Natural Sciences is under the heading of Biological Sciences. The instructional plan is organized around three principles: energy, transportation systems (plants and animals), obtainment and consumption of oxygen. The plan lacks activities/objectives for this year.

Third Year ... Natural Sciences is under the heading of Biological Sciences. The instructional plan is organized around the following processes: metabolism, coordination of functions, genetics and reproduction. The plan lacks activities/objectives for this year and only provides details of contents under the main headings.

Fourth & Fifth Years ... At the beginning of these two years, the students choose an orientation. Those who choose Science as their orientation have three choices: social sciences, natural sciences and "exact" sciences (chemistry, mathematics, etc.).

Those who choose Natural Sciences have six courses in a two-year period. The first one is on "Education for Health," where the main concepts are health, environment and illness. The second one is on "Biological Sciences," where animal physiology (nutrition, respiration, etc.) is discussed. The third and fourth courses are laboratory practice. The fifth one is "Physical Anthropology," and the sixth one is "Biological Sciences," where the main concepts are adaptation of organisms to their environment, evolution, mutation, fossil evidence, evolution of living beings, evolution of man and evolution of the sciences.

The plan for the six courses consists only of a list of topics. The remaining students, those who choose social sciences or exact sciences, have very short courses or none on biology-related subjects.

Evaluation of Curricular Programs

Mechanisms have not been articulated for updating and constantly reevaluating these curricula. The lack of evaluation of these curricula makes it impossible to accurately assess their success (or lack thereof).

There are instructional materials available, including several textbooks, but most of them are poorly structured and often inaccurate or misleading; current conceptual understanding generally is not incorporated into these texts.

The preparation of future teachers needs drastic reform. Current content and pedagogical instruction is inadequate and teachers are not prepared to teach the current curricula. The situation will worsen in coming years unless teacher preparation becomes much stronger.

Recently, the central government, 10 provinces and the city of Buenos Aires, agreed to a pilot evaluation of student performance in the areas of Spanish and mathematics. More than 2000 students — 1174 students in the last year of elementary school and 1074 students in the last year of high school — were evaluated. In general, the performance of students was poor (i.e. only 33.47% of the students in elementary school were able to deal with fractions). This pilot evaluation was a step to the creation in the near future of a national system for evaluating education.

Conclusions

Argentina has impressive human and natural resources, but political conflict and uneven economic performances since World War II have impeded full realization of its considerable potential.

The lack of budgetary resources is the most serious problem facing the Argentina educational system. The consequent low salaries for teachers are the cause of frequent strikes that seriously disrupt the educational system. Teachers also lack the necessary resources, the time to reflect, and the opportunities to share ideas with other teachers. Under such conditions, it is difficult to instill a sense of exploration, curiosity or excitement in today's students.

In summary, there are three observations made concerning "Biology Education in Argentina" in this report:

1. In all grades, too little time is spent on biology instruction. Teachers and students should spend at least one hour a day on biology at all grades and take advantage of the many opportunities to connect biology to other school subjects.

2. All students need to learn more, and often different, biology. Important themes (especially in high school) are not found in the curriculum. The following are examples of missing themes:

- Biodiversity and its loss.
- Personal, social and ethical aspects of biology.
- Nature of technology.
- Biotechnology.
- The biological basis of behavior.
- Human influences on the biosphere.
- Overpopulation and resources.

Such oversight is the consequence of the lack of a modern curriculum framework.

3. There is a need to develop active learning environments through better use of discussions, laboratories, field experiences and educational technologies, all under the umbrella of inquiry-oriented instruction.

Contributed Paper

Biology Teaching in Brazil

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Organization of the Educational System

The Brazilian educational system is organized in two levels. There are eight grades in the first level (grade school) and three grades in the second level (high school).

In the first four years of grade school, there is only one teacher per class who teaches all subjects. In the next four years of grade school, biology comes under the general heading of "Science," a subject which also includes physics and chemistry.

Students spend from four to five hours per day in school, and classes last 50 minutes each. Thus, a period amounting to only 12-15% of total school hours is dedicated to the teaching of science in grade school.

The high school course consists of only four to five school-hours per day, which means, in the best of cases, 25 hours per week of schooling. Of this total, only 15% is dedicated to the teaching of physics, chemistry and biology.

The quantitative problem is only one of the obstacles to the scientific training of Brazilian citizens since even the reduced time is poorly used, as will be demonstrated by our analysis of biology-teaching contents and methods.

Each federate unit (state or territory) is free to draw up its own curriculum, which means that teaching proposals and programs vary greatly. However, most of the science programs follow a basic pattern in the first four grades.

Biology, as a science, has undergone great transformations within this century, evolving from a descriptive and taxonomic study to a quantitative experimental science with basic unitary concepts applicable to all living beings. The phenomenon of diversity, the concept of evolution, and genetic continuity are basic themes in modern biology. However, there is a very marked gap between scientific progress and the educational system. The latter changes slowly due to a lack of mechanisms for quick assimilation of these advances. Biology programs in Brazilian high schools reflect this situation.

The tendency to be descriptive prevails in 96% of the curricular proposals when the subject being dealt with is "cell structure," and 70% when the subject is "cell metabolism."

Analysis of the diversity of living beings and man's attempts to understand it are the essential basis for understanding scientific procedure. Biology curricula, when dealing with the variety of species, rarely focus on this aspect of the discipline, but concentrate instead on morphophysiologic descriptions of various groups without establishing relationships among them.

Curricular proposals are diversified in the way they present biological information. Some emphasize functions, pointing out processes that are common to animals and vegetables. Others maintain the traditional divisions of botany and zoology, describing group by group. The concept of biology as science appears in only approximately 50% of the programs.

The science—technology—society relationship and the historical context of the evolution of biology seldom appear, indicating the slight concern with analysis of the social implications of scientific and technological development, a subject that is considered essential to today's science.

Taking into account the similarity of the topics among the programs analyzed, it is possible to state that although content is similar there are no national education goals. This fact explains why there are no great discrepancies between the high school programs and the college entrance exams. In the cases in which it was possible to compare the two documents, there was an overlapping of topics, as well as their sequence, which in turn reflects the influence of the more popular textbooks, the true "curricular dictators."

Primary School Programs

1st Grade ... human systems, senses, nutrition/diets.

2nd Grade ... living beings, classification (animals and plants), organism relationships.

3rd Grade ... organisms, soil, climate.

4th Grade ... man and environment, biological changes of human beings, health, reproduction and development.

5th Grade ... plants, soil, climate, agriculture, distribution of animal and plants.

6th Grade ... organisms and chemical reactions, nutrition, respiration, excretion, food production.

7th Grade ... life and energy, photosynthesis, food chains, ecosystems.

8th Grade ... reproduction in different groups, cell structure and function, genetics and evolution, nervous systems, hormones, behavior.

High School Programs

Year 1 ... origin of life, cell, cytology— structure and function, metabolism, cell theory, animal and plant histology.

Year 2 ... taxonomy, classification criteria, animal form and function, plant form and function, embryology, reproduction and human development, Mendelian genetics, population genetics, evolution, theories, mechanisms.

Year 3 ... ecology, population, organism associations, biogeography, man and environment.

Teaching Methods & Content

A qualitative analysis of Brazilian science teaching unveils a regrettable reality that cries out for urgent corrective measures.

Professionals interviewed, when asked to characterize the teaching of biological sciences in Brazilian high schools, use very critical expressions such as "precarious" (30%), "deficient" (30%), "dreadful" (15%), and "very bad" (10%), while others consider it disappointing or disheartening (15%). None of those interviewed considered the teaching of biology to be good or even reasonable.

Such qualification is justified by reasons such as "the content is superficial and outdated" and "sticks to conservative academic curricula that fail to deal with topics relevant to the students." The lack of links with youths' daily lives or the use of regional approaches are also frequently deplored by specialists working in the universities as well as those working in the school system.

When questioned about the methodological aspects that they feel contribute to the poor performance in biology, the most common criticism is that the classes are largely theoretical, based on a textbook. The method elicits terms such as "book learning" and "memorization" — a method that emphasizes the learning of facts and data, to the detriment of the collective analysis approach to problems presented by the teacher.

Curriculum-related problems indicate, in the first place, the poor quality of the textbooks available on the market, as well as the students' difficulties in purchasing them. The content of textbooks is closely related to the concern to insure factual teaching, and is determined by the content of college entrance exams and by irrelevant and outdated programs of the state departments of education. These institutions have produced curricular materials comprised of lists of content topics, objectives of the various disciplines, suggested class activities and a bibliography. Many educational problems are attributed to these documents, even though they have no legal regulatory force.

Testimonials indicate that teachers faithfully follow the order of the themes dealt with in the compendiums, rarely attempting to go any further; when they seek greater student participation, it is only by means of individual or group answers to the questions given in the books themselves. These questions require only the transcription of portions of the text itself, and not the slightest intellectual effort is necessary to solve the problems themselves.

Some consider that the great majority of theoretic teaching stems from the lack of or precarious nature of school laboratories and from the lack of preparation of the teachers and their unwillingness to improvise experiments with ordinary, easily obtained material. It should be pointed out that, in certain cases, the school has labs, but the teacher does not have access to material or equipment needed to carry out experiments, due to bureaucratic reasons or to insufficient funds. This limitation is the result of lack of funds or lack of components, substances or specimens on the market. There have also been inappropriate purchases made by the state departments of education, without consulting the teachers. The lack (or deficiency) of technical aid in preparing and maintaining material is another factor that adds to the difficulty of organizing practical classes.

Excursions aimed at contact with elements of the community and with different ecological situations are very rare. The difficulties that prevent this type of activity are the overly-strict adherence to schedules, lack of transportation, problems of student safety, teachers' resistance to face unknown situations, and overly large number of students per class.

Teacher Preparation

Teacher training courses have been the object of criticism since they were begun. The situation worsened towards the end of 1968, when there was great expansion in higher education, leading to the creation and installation of schools with ill-prepared teachers. A teacher's lack of preparation leads to insecurity upon facing a class, low quality of classes, and to a great dependence on textbooks. The results of exams given by the Board of Education to select public school teachers confirm this.

In some regions, other problems are added to those mentioned above, such as the lack of specifically trained science teachers. According to our data, in many regions this deficiency is filled by college graduates of completely different fields, such as dentists, pharmacists, engineers, nurses, or even college

students who work in grade schools or high schools prior to graduation.

The picture is tragic. Teachers are so poorly paid that they are obliged to give an exaggerated number of classes, often in two or three different schools. This difficult situation leaves the teachers with scant time to prepare courses and coordinate with other teachers, thus jeopardizing integration of the various disciplines. Evaluation is thereby also affected and reduced to simple, easily corrected, multiple choice tests.

What one finds in practice is a relationship of dependence on a centralized decision-making system. The teachers' insecurity, incapacity and poor working conditions do not permit them to initiate their own teaching projects.

Curriculum–Renewing Projects

Since the 1950s, substantial investments were made in Brazil to improve science teaching and alleviate the deplorable situation described above. Various projects with diverse curriculum renewal objectives were developed, influenced by international developments.

At the same time, and even prior to the curriculum-renewing movements that began in the United States and Europe, the Brazilian Institute of Science Education and Culture (IBECC) was already drawing up projects to improve science teaching as a contribution to the country's economic and scientific development. This institute's work was aimed at updating curricular content and manufacturing material for lab classes. In the 1960s, the Education Ministry created "science centers" in the country's main state capitals.

What came to be known as the first generation of curricular projects were very important at that time and even today. These projects were translated and adapted to the Brazilian school system. The Federal Government has lent ongoing support to biology teaching and has sponsored several projects in Brazilian institutions. A new academic community is being formed at the same time, that of the science educators whose main base is the universities and professional associations.

At present, science and biology teaching continues to be an object of concern. As part of the efforts to support national scientific and technological development, the "Education for Science" program is aimed at identifying themes, improving teacher training, and supporting the quest for local solutions to improve teaching and to stimulate research and the implementation of new methods.

One of the projects proposes the study and revision of current biology programs. It will be a step toward the necessary broad-based and in-depth reform in the teaching of science disciplines.

Appendix A

Basic Biological Concepts of Human Behavior

(Excerpts from a contributed symposium paper.)

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Our knowledge of human biology, evolution, ethology, and evolutionary anthropology has expanded dramatically during the last 30-50 years, clearly demonstrating that human societies can be studied and understood on the basis of a combined analysis of both biological and cultural factors.

Man is a member of the animal world. What nevertheless sets him apart from the animals is his behavior, developed and constrained by both environmental and genetic factors. If different cultures are examined, behavior shows wide variations but also certain general features. All cultures are based on language, and human languages, as different as they may be, represent a well-defined class of communication mechanisms.

Characteristic of all cultures is a hierarchial order of human relations, including a mechanism of structuring power — i.e. the kinship system. Although it is again clear that kinship systems show large variations across societies, all people living in a society reckon with relatives and classify them in some way, which means that the ability to develop a system of kinship is a biological trait of our race.

A third characteristic of cultures is the use of artifacts. It is a biological feature of man that he has an affection for objects of all kinds, and it is hard to imagine an active human being without artifacts. Of course, there are substantial differences among cultures regarding the sophistication and abundance of artifacts produced and used.

The fourth characteristic is the existence of ideas. Ideas can be understood as organized thoughts which are built from the simplest units that can be considered meaningful, hereinafter referred to as concepts. Ideas may be simple habits, techniques, tales, myths, values, and norms, but they may also appear in the form of artifacts as instruments, tools, or items of cults or arts. Ideas or artifacts are characteristic of all cultures and are specific biological features of man.

These four defining characteristics of human cultures can be traced back to three purely biological features, namely social affection (Eibl-Eibesfeldt 1989), fondness for objects (Morris 1962) and the ability to follow rules (Eibl-Eibesfeldt 1982).

Cohesion in Group & Modern Societies

Highly-developed *Homo sapiens* dominate their animal and plant environment but also represent a significant threat to each other. Such intra-race competition led to the evolution of *Homo sapiens* groups speaking the same languages, using similar artifacts, cooperating with members of the group, accepting moderate hierarchy, and obeying a strict set of rules based on culture. It is the ideas developed in these groups that are regarded as the most important organizing factor of human group societies.

Through time, there evolved large mass soci-

eties consisting of numerous group societies. The development of these huge human masses rendered the competition of ideas possible, something that was unthinkable in group societies. Nevertheless, socialization, early learning, and extremely strong traditions have allowed the ideas of group societies to survive.

In group societies, ideas are protected from challenges through an early socialization process. For example, in a group society, the myth of origin does not necessarily have to be logical and convincing. As there is only one myth of origin, all members of the society accept it. On the other hand, the ideas in the mass society are continually exposed to challenges so that, for example, the myths of origin have to be harmonized with the ideas of science and practice, as well. In mass societies, an idea can organize enormously large groups but only if the concept elements forming the idea include those needed for the longer existence of such large groups. Propaganda and ideology appear as important organizing tools for the perpetuation of ideas.

Thus, contrary to the mechanisms of ethological group determination, the greatest advantage of a society organized by ideas is the appearance of idea competition that offers a basis for the development of modern science, for example. Individuals in group societies have always been secure in accepting the ideas of the group; now individuals in mass societies must choose from a huge array of competing ideas without there being an idea embracing everything and guiding their choices. This is one explanation of the alienation of modern man, who loses his self confidence and value in mass society.

The Ethological Nature of Power

All social animals develop a dominance system in their groups, and individuals contest, from time to time, their position in it. A stabilized order of rank guarantees the distribution of resources among group members with a minimum expenditure of energy, and thus it is of great significance for the survival of the group. No social organization exists without a hierarchy.

In human groups having language and culture, the higher positions are determined by ideas; that is, by rules of behavior. As we have seen before, these ideas and rules of order are biologically based, and therefore, there are biological factors that determine the source and nature of power in society.

On a purely biological basis, in groups of 50-60 people, a unified order of dominance could not develop. Ideas make it possible, however, to regulate, by means of rules, the order of dominance in masses of many thousands or even many millions of people. A normal functioning of the society is usually already assured by the socialization of the dominance of rules during early childhood. If early socialization is defective, masses will appear which accept the given structure of rules only partly, if at all, and this may lead to a slow disintegration of the society.

Biological Factors Underlying the Idea of Possession

Man has an affection for objects and has a strong sense of the dominance of order. These two characteristics are sufficient to explain the emergence of simpler forms of ownership in the course of social development. It is easy to understand now that, in the course of the evolution of culture, the appearance of ideas changed the mechanisms concerning ownership as well. The development of the ability to respect rules makes it possible for ownership to attain an incredible complexity. It is possible now to exactly define the nature and the

limits of the possession in question, as well as the rights of the owner, etc.

Parallel with the development of modern mass societies, conflicts relating to ownership or the right of disposal have also developed. If no limiting rule is built into the idea of possession, private property is very detrimental to the society as a whole, as it allows huge values to become dependent on the decision of one person. Thus, very early, the creation of ideas began which regulated the dominance concerning ownership, in the interest of society.

In the early societies, the reward for man was the success in obtaining consumable goods and a place, the highest possible that he could occupy, in the hierarchy of the group. The appearance of property and dominance circumscribed by rules dramatically enlarged the scale of obtainable rewards, but the motivation behind the rewards remained the same. Obtaining ownership or right of disposal over objects is one of the main motivating forces of man; the other is the acquisition of social dominance.

Human Needs in an Ethological Perspective

There are three basic categories of human needs: physiological, ethological, and cultural. Physiological needs are obvious, such as water, food, shelter, sleeping time, and adequate health care. Cultural needs depend on the particular cultural setting. Ethological needs are not always obvious, but the following list summarizes the most important ones:

- The opportunity to express affection and be the subject of social affection. Humans need social affection.
- The opportunity to communicate. If the need for social affection is satisfied, possibly most of the need to communicate also finds an appropriate outlet.
- Social status. Humans need to belong to social networks and hold well articulated status.
- Possession of artifacts. Humans need to possess some artifacts which they permanently own and can arrange freely in their home spaces.
- A final, more comprehensive human need is connected with ideas. Every human being needs opportunities to practice his/her idea-constructing ability and to enjoy the pleasure of acquiring the ideas of others.

References

Csányi, V. (1989). *Evolutionary systems and society: A general theory of evolution.* Durham, NC: Duke University Press.

Eibl-Eibesfeldt, I. (1982). Warfare, man's indoctrinability and group selection. *Z. Tierpsychol.* 60, pp. 177-198.

Eibl-Eibesfeldt, I. (1989). *Human ethology.* New York: Aldine De Gruyter.

Morris, D. (1962). *The biology of art.* London: Knopf.

Appendix B

Biological Concepts Taught in Grades 11 & 12 in Indian Schools

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The education system in India can be described as 10+2+3. The following concepts are taught at the +2 stage (i.e. grades 11 and 12 of the school system). The purpose of teaching biology at this level is two-fold; firstly, to prepare students for the academic and professional courses at the tertiary level of education and, secondly, to prepare those who drop out after the senior secondary stage to meet the challenges of life in the world of work.

The concepts have been divided into nine units, as follows:

Unit One: The Living World
- Nature and scope of biology.
- Being alive.
- Life — its origin, evolution and maintenance.

Unit Two: Unity of Life
- Cell as a unit of life.
- Biomolecules of the cell.
- Cellular macromolecules.
- Enzymes.
- Biomembranes.
- Structural organization of the cell.
- Cellular respiration.
- Cell reproduction.

Unit Three: Diversity of Life
- Diversity of life.
- Taxonomy and phylogeny.
- Monera.
- Protists.
- Plant kingdom.
- Fungi.
- Animal kingdom.
- Invertebrates.
- Chordates.

Unit Four: Organism and Environment
- Species.
- Population.
- Community.
- Ecosystem.
- Biosphere.
- Conservation of natural resources.
- Wildlife conservation.
- Forest conservation.
- Biological rhythms and animal behavior.
- Environmental pollution.

Unit Five: Multicellularity in Plants — Angiosperms
- Morphology and anatomy of flowering plants.
- Absorption and movement of water in plants.
- Mineral and nitrogen nutrition in plants.
- Photosynthesis.
- Reproduction in flowering plants.
- Growth and development of flowering plants.

Unit Six: Multicellularity in Animals
- Animal tissue.
- Animal nutrition.
- Respiratory gas exchange.
- Circulation of body fluids.
- Excretion and osmoregulation.
- Movements and locomotion.
- Control and coordination — nervous system.
- Control and coordination — endocrine system.

•Animal reproduction.
•Embryonic development.
•Growth, repair, regeneration, aging, death.

Unit Seven: Continuity of Life
•Elements of heredity and diversity.
•Genes and chromosomes.
•Genetic material — its replication and transcription and translation.
•Gene expression and its regulation.

Unit Eight: Origin and Evolution of Life
•Origin of life.
•Relationships among organisms and evidences of evolution.
•Theory of evolution by natural selection.
•Human evolution.

Unit Nine: Application of Biology
•Domestication of plants and crop improvement.
•Domestication and improvement of animals.
•Agricultural chemicals — pesticides.
•Biofertilizers and biological pest control.
•Genetic conservation and new crops.
•Understanding human diseases.
•Common human diseases.
•Mental health, addiction and community.
•Technology for medical applications.
•Biotechnology.
•Bioenergy.
•Growth of human population.

Appendix C

Biological Concepts Taught in Malaysian Schools at Grades 10-11

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The main biological concepts are taught under four major themes:

A. Man & Maintenance of Life
Grade 10
The Cell as a Basic Functional Unit of Life
•Structure and function of the cell.
•Transport processes across the cell membrane.
•Cell organization.
•Cell division.

Food and Nutrition
•Diet.
•Enzymes.
•Food digestion.
•Food absorption and storage.
•Nutritional requirements of plants.
•Photosynthesis.
•Nutrition and food technology.

Respiration and Life
•Respiration and release of energy.
•Types of respiration.

Grade 11
Care and Maintenance of Body Systems
•Blood and its functions, blood circulation.
•Lymph system and its function.
•Homeostasis.
•Transport system in plants.

Movements and coordination
•Support systems.
•Nervous system.
•Biochemical system.
•Tropism.

B. Man & Balanced Living
Grade 10
None

Grade 11
Reproduction
•Meosis and mitosis.
•Physiological changes in the reproductive system.
•Prenatal development.
•Reproductive technology.
•Reproduction in plants.
•Technology underlying tissue and asexual reproduction.

Variation and inheritance
•Introduction to genetics.
•Genetics — historical perspective.
•Mendel's Laws 1 and 2.
•Variation.
•Sex determination.
•Contributions of genetic research to society.

Growth
•Understanding growth.
•Growth graph.
•Growth in human beings.
•Growth in animals.
•Growth in plants.

C. Man & His Environment
Grade 10
Equilibrium in the Environment
•Diversity of organisms.
•Ecosystem, population, colonization.

•Interaction among organisms.

Environmental Management
•Environmental quality.
•Development.
•Pollution.
•Care and protection of environmental quality.

Grade 11
None

D. Man & Social Health
Grade 10
Personal and Community Health
•Personal hygiene and physical health.
•Mental health.
•Community health.

World health problems
•Health issues and problems in the world.
•Care and prevention of communicable diseases.

Grade 11
Microorganisms and Their Impact on Living
•Historical developments in microbiology.
•Types of microorganisms.
•Factors controlling microorganisms.
•Useful microorganisms.
•Harmful microorganisms.

The following are the main questions associated with the above mentioned themes:
•What is biology?
•Why learn biology?
•How is biology studied?

Form VI or "A" Level (Grades 12-13)... Post Secondary or Pre-University
Cell Biology
•Chemical basis of life.
•Water, air, food (carbohydrates, proteins, fats, minerals), substances.
•Cell processes.

Enzymes
•Action of temperatures and pH on enzyme activity.
•Characteristics of enzymes.
•Enzyme specificity, enzyme actions and results.

Cell
•Structure and functions in animals and plants.
•Mitosis and meiosis.
•Nucleic acids and genetics.
•DNA, RNA, structure and functions.
•Gene concept.

Plant and Animal Physiology
•Holophytic plants: structure and functions.
•Photosynthesis, transport system.
•Holozoic animals — balanced diet, digestion, transportation, absorption and storage of food.
•Energy production — respiration, respiratory structures and functions, supply and demand of oxygen, transport of oxygen, aerobic and anaerobic respiration.
•Homeostasis — heat production and control of temperature in plants and animals.
•Endocrine system — hormone manufacture, transport and actions.
•Nervous system — structure and functions, voluntary and involuntary actions, evolutionary development of nervous system.
•Transport and translocation in animals and plants — mechanisms, structure.
•Reproduction and growth — sexual and asexual reproduction.

Evolution
•Variation (genotype, phenotype).
•Genetics — monohybrid, dihybrid ratios; role of chromosomes in inheritance, RH factor.
•Theories of evolution — Darwinism, natural

selection, classification.
•Taxonomy of organisms — versus plant and animal kingdoms survey.

Organisms and Their Environment
•Habitat , niche, ecosystem, community.
•Energy transfer.
•Interaction and population.
•Quantitative ecology.
•Use of quantitative ecology.
•Use of quantitative methods.
•Use of keys.

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